Bulletin No. 314 Series A, Economic Geology, 94

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

REPORT

ON

PROGRESS OF INVESTIGATIONS OF MINERAL RESOURCES OF ALASKA

IN

1906

By ALFRED H. BROOKS AND OTHERS

WASHINGTON
GOVERNMENT PRINTING OFFICE
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CONTENTS.

ILLUSTRATIONS.

REPORT ON PROGRESS OF INVESTIGATIONS OF MINERAL RESOURCES OF ALASKA IN 1906.

By Alfred H. Brooks and others.

ADMINISTRATIVE REPORT.

By Alfred H. Brooks.

PREFACE.

This volume, like those previously issued,[a] will (1) summarize the results of the field work in Alaska for the year and (2) present a concise statement of the advancement of the mining industry in the Territory. It affords a means of giving to the mining public the important results of investigations that are underway or completed, pending the appearance of the more elaborate reports, always slow of preparation as well as of publication. Many of the papers contained in this volume have been prepared before the completion of the study of the material collected, and hence the conclusions advanced may not be accepted with the same authority as those contained in the detailed reports to be issued later. Nevertheless, it is believed that these preliminary statements are of value to the prospector and miner, even if they should be regarded only as suggestions.

As in former volumes, the papers here presented fall into three groups—(1) summaries of progress in various phases of the mining industry during the year, (2) preliminary accounts of investigations in progress or completed, and (3) statements of the results of minor investigations not to be published elsewhere.

The attempt is here made to cover the entire field of Alaska mining interests; but to do this it has been necessary to use, in part, information compiled from various sources. It is obviously impossible for the twelve geologists attached to the Alaska division to visit annually all the mining districts in the Territory and at the same time to carry on the more important work of studying the conditions of occurrence and

[a] Report on progress of investigations of mineral resources of Alaska in 1904: Bull. U. S. Geol. Survey No. 259, 1905; idem, 1905: Bull. U. S. Geol. Survey No. 284, 1906.

distribution of the mineral deposits. It has been possible, however, to collect through correspondence considerable information in regard to the status of mining in the districts that were not visited by members of the Survey. The writer would here make acknowledgment to the many Federal officials, mine operators, and prospectors who have cooperated in the collection of these data.

The statistics presented on later pages show that the value of the mineral production in Alaska still comes very largely from the placers. Therefore the description of placer districts—the most important source of the mineral wealth—predominates in this report as in previous volumes. Again, as in previous years, a large part of the investigations and surveys were directed to the mapping of the placer districts of the Yukon and Seward Peninsula, which are the largest producers.

The composite authorship of this volume is evident from the fact that fifteen different papers are presented by eleven different authors. The arrangement of the contributions is, in general, geographic—from south to north. It is unfortunate that the exigencies of prompt publication make it imperative to omit all elaborate illustrations, the reproduction of which necessarily consumes considerable time, and to include only such outline maps and diagrams as can be quickly prepared for printing.

PROGRESS OF SURVEYS.

INTRODUCTION.

In 1906 fourteen parties were engaged in field work during a period varying from two and a half to six months. The technical force of these parties included twelve geologists, four geologic assistants, four topographers, and two hydrographers, in addition to which about thirty camp men were employed. Eight of these parties carried on geologic investigations, two made topographic surveys, three combined both classes of work, and one was employed in stream measurements and hydrographic reconnaissance. The aggregate of the areas covered by geologic reconnaissance surveys during 1906 is 9,000 square miles; by detailed geologic surveys, 548 square miles. Topographic reconnaissance surveys were carried over an area of 10,768 square miles; detailed topographic surveys, over an area of 40 square miles. Detailed hydrographic surveys were made over an area of 200 square miles and reconnaissance surveys over an area of 1,000 square miles. In addition to this, of the 28 Alaskan mining districts in which work is going on, 16, including all but one of the large producers, were visited by members of the Survey. The table on the next page presents a summary of the progress of surveys since the organization of systematic work in 1898.

Progress of surveys in Alaska, 1898–1906.

Year.	Appropriation.	Areas covered (square miles).					
		Reconnaissance geologic.	Detailed geologic.	Reconnaissance topographic.	Detailed topographic.	Reconnaissance hydrographic.	Detailed hydrographic.
1898	$46,189.60	9,500		14,912			
1899	25,000.00	6,000		8,688			
1900	25,000.00	10,000		11,152			
1901	35,000.00	12,000		15,664			
1902	60,000.00	17,000		20,304	336		
1903	60,000.00	13,000	336	15,008			
1904	60,000.00	6,000		6,480	480		
1905	80,000.00	8,000	550	8,176	948		
1906	80,000.00	9,000	414	10,768	40	1,000	200
	471,189.60	90,500	1,300	111,152	1,804	1,000	200

Although the actual areal surveys are tersely summarized in the above table many of the results can not be presented in this form. For example, practically every mining camp in Alaska has been investigated—some of them in great detail—yet the areal results of this class of surveys are very meager. This will account for the fact that with increased appropriations there has not always been an increase in the areas surveyed. Then, too, in the last three years much of the funds has been spent in detailed surveys, which, to speak roughly, cost ten times as much as the reconnaissance work.

The above table shows that nearly 500,000 [a] square miles in Alaska have not been covered by geologic reconnaissance surveys. Until this work is much more nearly completed all generalizations on the distribution of the mineral wealth must remain largely hypothetical.

Preliminary topographic surveys, including about 50,000 square miles covered by other Government bureaus, have been carried over less than a quarter of the entire area of Alaska. The importance of the rapid extension of such surveys can not be too strongly emphasized, for they furnish not only a guide to the prospector, but are absolutely essential to all engineering enterprises.

It is worthy of note that although nearly half a million dollars has been spent on Alaskan surveys and investigations this is only about one-half of 1 per cent of the value of the gold output from the Territory during the same period.

GEOGRAPHIC DISTRIBUTION OF INVESTIGATIONS.

GENERAL.

As in previous years, much of the time of the geologist in charge was given to administrative duties. The general supervision of the topographic work continued in charge of Mr. Gerdine. During the writer's absence in the field Frank L. Hess looked after the office affairs of the division.

[a] The area of Alaska is 586,400 square miles.

In June, 1906, the writer joined Mr. Kindle at Eagle and together they made a careful study of the geology along the upper Yukon. The main purpose of this work was to gather data which would serve to elucidate the stratigraphic problems, but incidentally some facts were obtained bearing on the occurrence of placer gold and of coal. From Circle the writer went overland to Fairbanks, making an examination on the way of the Birch Creek placer district. A few days were then spent in the Fairbanks district. At the invitation of Maj. W. P. Richardson, the writer joined the party of J. L. McPherson, engineer of the Alaska road commission, and carried a geologic reconnaissance westward from Fairbanks to the rapids on the Yukon, including a brief visit to the Rampart district. The month of September was spent in Seward Peninsula, with the Moffit and Hoyt parties, and in making a study of the Kougarok placer district.

After returning to the office the writer was occupied in preparing a statistical report on the gold and silver production of Alaska in 1905, which has been published in the Mineral Resources of the United States, 1905.

To W. W. Atwood was assigned the task of studying the stratigraphy of the Cretaceous and Tertiary coal-bearing rocks in the Territory, with the purpose of establishing correlation and obtaining information on the relative commercial value of the different fields. The details of this investigation are referred to in another place.

SOUTHEASTERN ALASKA.

The close of the last season witnessed the completion of the preliminary geologic mapping in southeastern Alaska as far northwest as Lituya Bay. There still remains, however, the survey of the Chilkat basin, the inland parts of the larger islands, and the more inaccessible portions of the high ranges. The work of last year embraced an area of about 3,000 or 4,000 square miles, extending northwestward from Lynn Canal to Lituya Bay and including a part of Chichagof Island. This survey was carried on by F. E. and C. W. Wright, assisted by R. W. Pumpelly. Though it was principally geologic some topographic reconnaissance surveys were made and much information was obtained on the retreat of the glaciers in the Glacier Bay region. At the close of the season C. W. Wright visited the Juneau and Ketchikan districts to collect data on the mining progress.

The urgent demand for detailed surveys of the more important mining districts in southeastern Alaska has been met so far as the funds available would permit. In 1906 R. B. Oliver made a survey, on a scale of a mile to the inch, of the more important parts of the Berners Bay district, embracing an area of about 40 square miles.

YAKUTAT-ALSEK REGION.

R. S. Tarr, assisted by B. S. Butler, continued his work in the Yakutat Bay region. He had hoped to cross the Malaspina Glacier to Cape Yaktag, but the fissuring which had taken place in this ice field since his previous visit in 1905 made it utterly impossible to carry out this plan. Mr. Tarr's observations in this region showed that since 1905 an advance of some of the glaciers had taken place. This is, of course, exceptional for Alaskan glaciers, but nevertheless may have an important bearing on the location of railway routes where the fronts of ice sheets have to be traversed.

Eliot Blackwelder, assisted by A. G. Maddren, made a geologic and topographic reconnaissance from Yakutat Bay southward to Alsek River. It was also planned to ascend that stream to the international boundary, but a serious accident prevented the accomplishment of this purpose. A statement of Mr. Blackwelder's results appears on pages 82–88 of this report.

CONTROLLER BAY REGION.

G. C. Martin completed the mapping of the accessible coal and oil fields of the Controller Bay district, begun in 1905. He was assisted by C. E. Weaver, and W. W. Atwood spent about a month in his party. Mr. Martin also carried topographic surveys over an area of about 200 square miles in this region.

COOK INLET REGION.

W. W. Atwood, assisted by C. E. Weaver, studied the stratigraphy of the lignitic coal-bearing rocks on both the east and west shores of Cook Inlet. This was part of the general plan to study the coal-bearing rocks of Alaska, already referred to.

A party under the direction of T. G. Gerdine made a topographic and geologic reconnaissance survey of an area of about 7,200 square miles lying northeast of and adjacent to Cook Inlet. Mr. Gerdine, accompanied by Adolph Knopf as geologist, mapped the valley of Knik River, portions of lower Matanuska River, and the area about its headwaters from Chickaloon Creek northward. R. H. Sargent, topographer, accompanied by Sidney Paige, geologist, mapped the area as far as practicable between Susitna and Matanuska rivers as far north as Chickaloon Creek and Talkeetna River, with an additional small area south of Knik River on the east side of Knik Arm.

At the end of the season Messrs. Gerdine and Sargent completed a traverse of the shore line from Knik southward to the mouth of Kasilof River, and Messrs. Paige and Knopf visited the Cook Inlet placer fields.

SEWARD PENINSULA.

F. H. Moffit, assisted by P. S. Smith, completed the areal mapping of the Nome and Grand Central quadrangles. This work is the first attempt to make an exhaustive study of the geology of any of the placer districts. It is hoped that as a result of such investigations general laws for the occurrence and distribution of the placer gold of the peninsula may be formulated. Mr. Moffit presents a brief abstract of his conclusions on pages 126–145 of this report.

Mr. Smith, in addition to his work with Mr. Moffit, made a reconnaissance of some of the other placer districts of the peninsula,[a] both to gather data on the progress of mining and also to familiarize himself with some of the larger problems of the province.

Most placer mining is directly dependent on a supply of water; therefore a knowledge of the water supply is of first importance to this industry. The accurate determination of the mean discharge of any given stream must be based on observations extending through a long period of years to equalize the variations caused by abnormal seasons. Such an investigation was inaugurated at Nome during the last season. The area investigated embraced a belt of country about 20 miles wide, stretching inland from Nome to the Kigluaik Mountains, a distance of about 40 miles, and was chosen both because of its commercial importance and because the detailed maps were available for calculating the areas of stream basins. It is hoped that funds may be available to continue this work and to extend it to other parts of Alaska.

These hydrographic surveys were made possible only through the cooperation of the water resources branch, which detailed John C. Hoyt, an experienced engineer, to take charge. Mr. Hoyt spent about two months in the field, and the observations were continued by his assistant, F. F. Henshaw. A brief summary of results will be found on pages 182–186. The complete report has already been published.[b]

YUKON DISTRICT.

L. M. Prindle, assisted by C. S. Blair, made a geologic reconnaissance southwest of the lower Tanana, covering about 2,000 square miles. The Kantishna placer district and a part of the Bonnifield, as well as the Cantwell coal field, were embraced within the scope of the investigation.

E. M. Kindle, assisted by V. H. Barnett, made a careful study of the stratigraphy of the Paleozoic rocks of the upper Yukon basin. In the course of this work he ascended Porcupine River as far as the international boundary. This investigation has an important bear-

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[a] See pp. 146–163.

[b] Water supply of Nome region, Seward Peninsula, 1906: Water-Sup. and Irr. Paper No. 196, U. S. Geol. Survey.

ing on the correlation of the gold-bearing series of the Yukon-Tanana region.

Topographic reconnaissance surveys were carried westward from Fairbanks to the Yukon and southward to the Tanana by D. C. Witherspoon, assisted by R. B. Oliver. An area of 6,300 square miles was surveyed on a scale of 1:250,000. This completes the preliminary mapping of the Yukon-Tanana region west of the one hundred and forty-fourth meridian except for a narrow belt along the Tanana. In another season it is expected to complete the preliminary mapping of the area lying between Yukon and Tanana rivers and the one hundred and forty-second meridian.

PUBLICATIONS ISSUED IN 1906.

The following Alaska papers and maps were published by the Geological Survey during 1906:

REPORTS INCLUDING MAPS.

Baker, M., and McCormick, J. C., Geographic dictionary of Alaska, second edition: Bull. No. 299, 690 pp. (no maps).

Brooks, A. H., The geography and geology of Alaska; a summary of existing knowledge, with a section on climate by Cleveland Abbe, jr., and a topographic map and description thereof by R. U. Goode: Prof. Paper No. 45, 327 pp., 34 pls.

Brooks, A. H., and others, Report on progress of investigations of mineral resources of Alaska in 1905: Bull. No. 284, 169 pp., 14 pls.

Collier, A. J., Geology and coal resources of Cape Lisburne region, Alaska: Bull. No. 278, 54 pp., 9 pls.

Martin, G. C., Reconnaissance of the Matanuska coal field, Alaska: Bull. No. 289, 36 pp., 5 pls.

Moffit, F. H., and Stone, R. W., Mineral resources of the Kenai Peninsula: Gold fields of the Turnagain Arm region (Moffit); Coal fields of the Kachemak Bay region (Stone): Bull. No. 277, 80 pp., 9 pls.

Prindle, L. M., Description of the Circle quadrangle (one of a series on the Yukon-Tanana region): Bull. No. 295, 27 pp., 1 pl.

Prindle, L. M., and Hess, F. L., The Rampart gold placer region, Alaska: Bull. No. 280, 54 pp., 7 pls.

MAPS PUBLISHED SEPARATELY.

Casadepaga quadrangle, scale 1:62,500.
Grand Central special, scale 1:62,500.
Nome special, scale 1:62,500.
Solomon quadrangle, scale 1:62,500.

REPORTS IN PREPARATION, TO APPEAR IN 1907–8.

The following papers and maps are in various stages of preparation and will be published during 1907 and 1908:

REPORTS INCLUDING MAPS.

Blackwelder, Eliot, Geologic reconnaissance from Yakutat Bay to Alsek River.

Brooks, A. H., and Prindle, L. M., An exploration in the Mount McKinley region (including a description of the Kantishna and Bonnifield districts).

Collier, A. J., Hess, F. L., and Brooks, A. H., The gold placers of a part of the Seward Peninsula.

Grant, U. S., The geology and mineral resources of Prince William Sound.

Hoyt, J. C., and Henshaw, F. F., Water supply of Nome region, Seward Peninsula, 1906: Water-Sup. and Irr. Paper No. 196.

Martin, G. C., Geology and mineral resources of Controller Bay region.

Moffit, F. H., Hess, F. L., and Smith, P. S., The geology and mineral resources of the Nome and Grand Central quadrangles

Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins.

Prindle, L. M., Description of the Fairbanks and Rampart quadrangles (one of a series on the Yukon-Tanana region).

Spencer, A. C., The Juneau gold belt, Alaska; and Wright, C. W., A reconnaissance of Admiralty Island: Bull. No. 287.

Tarr, R. S., Geologic reconnaissance in Yakutat Bay region.

Wright, C. W., and Wright, F. E., Mineral resources of the Wrangell and Ketchikan districts.

MAPS TO BE PUBLISHED SEPARATELY.

Berners Bay special, scale 1:62,500.

Controller Bay region special, scale 1:62,500.

Northwestern part of Seward Peninsula, scale 1:250,000.

Northeastern part of Seward Peninsula, scale 1:250,000.

Southern part of Seward Peninsula, scale 1:250,000.

THE MINING INDUSTRY IN 1906.

By Alfred H. Brooks.

FOREWORD.

An increase of nearly 50 per cent in the value of the gold output of 1906 over that of the previous year is the most concrete evidence of the advancement of the mining industry in Alaska. That copper mining, too, has undergone a rapid expansion is manifest by an increase of at least 20 per cent in production over the previous year. Other mineral deposits, such as coal, marble, tin, and gypsum, have also received considerable attention. This progress has consisted chiefly in the development of the older districts rather than in the discoveries of new mineral fields, and can, therefore, be interpreted as an index of continuous advancement rather than abnormal expansion.

Though the placer mines of Nome and Fairbanks were by far the greatest producers of wealth last year, yet they have probably received less attention from investors than the problems of railway construction along the Pacific slope of the Territory. This is another indication of the healthy expansion of the commercial interests and augurs well for a long period of prosperity.

The influx of capital seeking investment in Alaska, so notable during the last few years, continued during 1906. A large number of prominent engineers have been engaged examining prospects and mines, as well as conditions of operating, transportation, etc., in the interests of prospective investors. Unfortunately, with the many legitimate enterprises there is an equal if not greater number of ventures which are promoted with a view of exploiting people ignorant of mining affairs rather than of developing mines. The public can not be too strongly urged to familiarize themselves thoroughly with the plans and assets of companies that invite popular subscription. Many honest promoters, because of their inexperience in mining affairs, mislead their equally inexperienced stockholders. Every such venture which fails retards the advancement of the mining interests by making investors suspicious of all other enterprises in the district.

STATISTICS.

The collection of accurate statistics of mineral production, a task much beset with difficulties even in well-settled regions, is in Alaska, with its indifferent mail facilities, as yet well-nigh hopeless. Up to 1905 no systematic attempt was made by the Geological Survey to gather statistics at first hand, the work being limited to distributing among the different districts, according to the best information available, the totals as published by the Director of the Mint. The first attempt to gather this kind of information was confined to estimates furnished by residents of the Territory and in many cases checked by the personal observations of the geologists working in various fields. By 1906 the improvement of the mail facilities and general accessibility of the country was deemed to have gone far enough to warrant an attempt to obtain statistics through schedules sent to the individual producers. This experiment was, however, only partially successful. Though nearly all the lode miners throughout the Territory have been prompt to reply and to send the desired information, the returns received from placer miners were very disappointing. Most of the small operators in the less important districts have, indeed, shown their willingness to cooperate in this statistical work by furnishing the desired information, but on the other hand the majority of the large operators, especially in the Nome region, have either ignored the request for information entirely or have returned the schedule without furnishing any information as to production. This seems particularly unjust, because it is the large operators who have benefited most by the work of the Geological Survey, and it seems as if they should have shown their good will by acceding to the request for information. In undertaking this work the writer believed that the mine operators would be the first to recognize its importance and would, therefore, be willing to cooperate. It has been a source of deep disappointment to him that such has not proved to be the case. While it may appear at first thought that by replying to the questions asked on the circular an operator is revealing information which might be used to his disadvantage, yet this fear is groundless, because the schedules are used only to make up totals of districts and all individual productions are held in strict confidence. It is the earnest hope of the writer that in the future mine operators may further the collection of reliable statistics and show their confidence in the Geological Survey by furnishing the desired information.

The following table of gold production is based on the best information available. The totals since 1898 are probably correct within 5 or 10 per cent, but the error in distribution of these totals among the various districts is probably much greater.

Value of gold production of Alaska, with approximate distribution, 1880-1906.

Year.	Pacific coastal belt.	Copper River and Cook Inlet region.	Yukon basin.	Seward Peninsula.	Total.
1880	$20,000				$20,000
1881	40,000				40,000
1882	150,000				150,000
1883	300,000		$1,000		301,000
1884	200,000		1,000		201,000
1885	275,000		25,000		300,000
1886	416,000		30,000		446,000
1887	645,000		30,000		675,000
1888	815,000		35,000		850,000
1889	860,000		40,000		900,000
1890	712,000		50,000		762,000
1891	800,000		100,000		900,000
1892	970,000		110,000		1,080,000
1893	833,000		200,000		1,038,000
1894	882,000		400,000		1,282,000
1895	1,569,500	$50,000	709,000		2,328,500
1896	1,941,000	120,000	800,000		2,861,000
1897	1,799,500	175,000	450,000	$15,000	2,439,500
1898	1,892,000	150,000	400,000	75,000	2,517,000
1899	2,152,000	150,000	500,000	2,800,000	5,602,000
1900	2,606,000	160,000	650,000	4,750,000	8,166,000
1901	2,072,000	180,000	550,000	4,130,700	6,932,700
1902	2,546,600	375,000	800,000	4,561,800	8,283,400
1903	2,843,000	375,000	1,000,000	4,465,600	8,683,600
1904	3,195,800	500,000	1,300,000	4,164,600	9,160,000
1905	3,430,000	500,000	6,900,000	4,800,000	15,630,000
1906 [a]	3,500,000	400,000	10,400,000	7,500,000	21,800,000
	37,465,400	3,135,000	25,481,000	37,262,700	103,348,700

[a] Preliminary estimates.

The silver production of 1906 is estimated to have been about 170,000 ounces, compared with 132,000 ounces in 1905. In 1906 the copper production is estimated to have been somewhat over 7,600,000 pounds, compared with 4,800,000 pounds in 1905. The output of other mineral products will be discussed in succeeding pages.

Estimated value of Alaska's mineral production in 1906.

Gold	$21,800,000
Silver	120,000
Copper	1,200,000
Coal	20,000
Miscellaneous, including tin, marble, etc	10,000
	23,150,000

TRANSPORTATION.

Transportation problems are still in the forefront throughout Alaska. Steamboat service, both on the rivers and oceans, is being rapidly improved, but with the exception of a few short railways overland transportation is still very primitive.

In Seward Peninsula two railways, referred to elsewhere (pp. 144, 153), have been extended, giving a total length of about 100 miles. In the Yukon region the railway from Fairbanks to Pedro Creek is doing a noteworthy service to the mining interests, but needs to be extended. On the Gulf of Alaska two railways are being constructed, one from Resurrection Bay and one from Cordova Bay, and other projects are

being earnestly considered. The railway situation, as regards inland extensions, leaves much to be desired, as the various interests are in many cases antagonistic. Current reports indicate that two important projects for a railway to the copper fields of the Chitina and the Controller Bay coal field are to be merged, which will assure early connection with these important mineral districts. Year by year the demand for railway connection of the inland region with open water on the Pacific becomes more imperative. Until such lines of communication are established, the development, if any, attainable by the interior districts will be very slight.

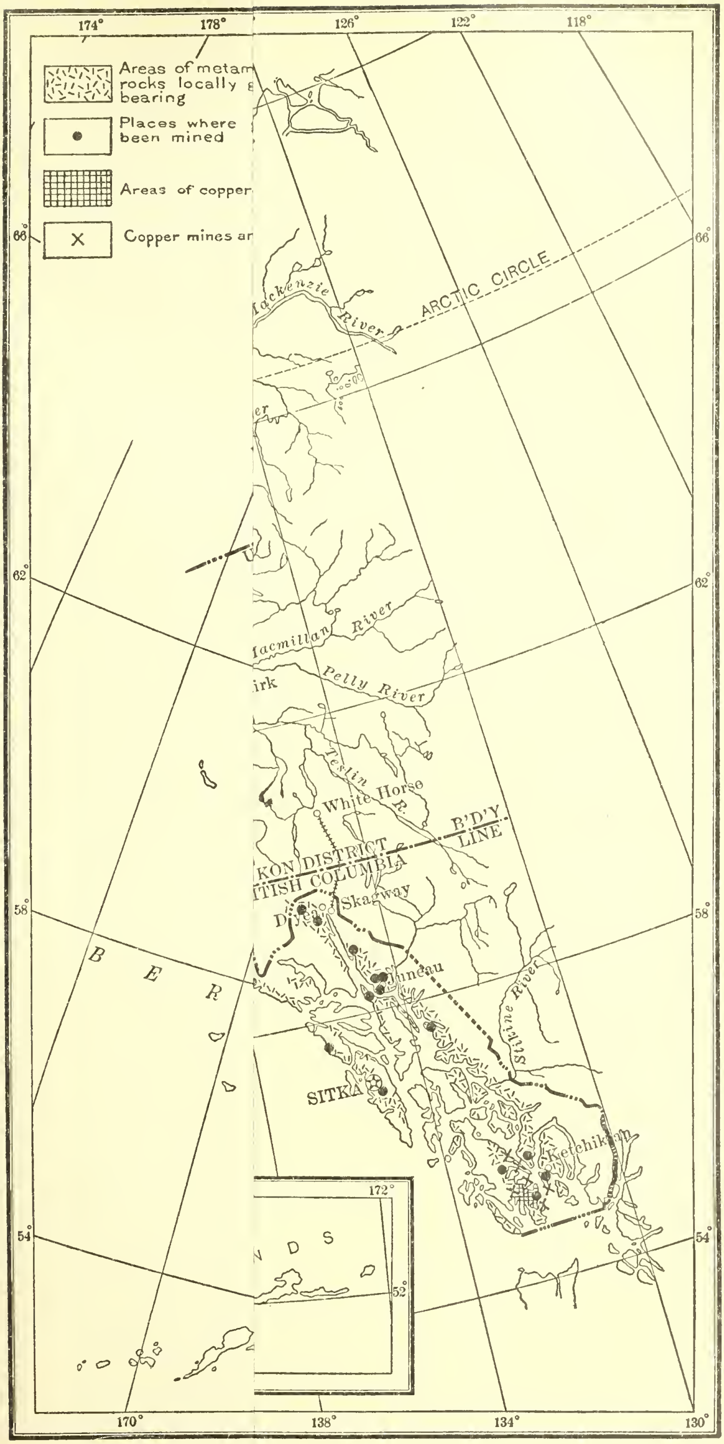
The Alaskan road commission, under the direction of Maj. W. P. Richardson, is doing much to help the mining interests in various parts of the Territory by highway and trail construction. As there is no form of local government outside of incorporated towns, the miner is entirely dependent on the Federal Government for the advancement of road construction, and it is to be hoped that the road commission may have sufficient funds to meet the many worthy demands for highways.

DISTRIBUTION OF PRECIOUS METALS.

It is the ultimate purpose of the geologic investigations carried on in Alaska to determine the laws governing the occurrence and distribution of the precious metals. Such a determination, however, must await far more detailed and comprehensive studies than have yet been accomplished. Meanwhile, with the progress of this work, there is an accumulation of evidence which suggests certain conclusions not yet susceptible of proof. As these may serve as a guide to the prospector, it will be desirable to set them forth briefly.

It has long been demonstrated that ore bodies, as a rule, occur in rocks which have been subjected to more or less alteration, or metamorphism, as it is usually called. Such metamorphism may be regional—that is, it may have been brought about by stresses in the earth's crust which have affected large areas—or it may be due to local disturbances, many of which are caused by intrusive masses. It is also possible that both regional and local metamorphism have affected the same formation. It should be noted that where there is any considerable metamorphism, both chemical and physical changes usually take place, as for example in the alteration of shale to schist or of granite to schist. These rock changes are important to the miner because, by increasing permeability, etc., they affect the occurrence of ore bodies, and necessarily the derived placers.

On the accompanying map (Pl. I) the distribution of the metamorphic rocks is indicated so far as they are known. These areas indicated as metamorphic have thus far been the wealth producers, as


Areas of metam
rocks locally
bearing
Places where
been mined
Areas of copper
Copper mines ar
ARCTIC CIRCLE
Mackenzie River
Macmillan River
Pelly River
Teslin R.
White Horse
B'D'Y LINE
KON DISTRICT
ITISH COLUMBIA
Skagway
Dyea
Juneau
Stikine River
SITKA
Ketchikan
B E R
N D S
174°
178°
126°
122°
118°
66°
62°
58°
54°
52°
172°
170°
138°
134°
130°

S KNOWN.

MAP OF ALASKA, SHOWING DISTRIBUTION OF GOLD AND COPPER-BEARING ROCKS, SO FAR AS KNOWN.

they contain over 99 per cent of all the gold mines in the Territory. It does not follow, however, that there are no precious metals outside of the metamorphic areas. For example, the Apollo mine on Unga Island, in southwestern Alaska, is in a series of comparatively recent lava flows which have been altered only very locally. Again, some of the Tertiary conglomerates in the Yukon basin are known to be auriferous, but it should be said that in this case the gold was undoubtedly derived from the metamorphic terranes. These exceptions to the general law are of importance because they show that other formations than those indicated as metamorphic may contain precious metals.

The map clearly shows that there are three general zones of metamorphic rocks in Alaska. One skirts the Pacific seaboard, stretches through southeastern Alaska, and appears to occur again on lower Copper River, on Kenai Peninsula, and on Kodiak Island. It is not to be inferred that this belt is made up entirely of formations of the same age, though such may prove to be the case. The map is intended simply to express the fact that in this belt there are considerable areas of metamorphic rocks. In southeastern Alaska these altered rocks belong to Paleozoic terranes, but to the west no definite age determination has been made.

A second and much larger belt of metamorphic rock lies to the north and west of the coastal zone, stretching from the international boundary through the Yukon and Tanana region, and appears to trend to the southwest, paralleling like the first the larger structural features of the Territory. This belt is broken near Yukon River by younger beds, but appears again in Seward Peninsula. A third belt, whose relation to the second has not been established, as the intervening areas are occupied by younger sediments, stretches through the upper Koyukuk Valley and is found again on the Kobuk. Though the map suggests that the easterly extension of this third zone should be found in the Porcupine Valley, yet the work of E. M. Kindle has shown that while the same rocks are probably present near the point where the international boundary crosses the Porcupine, they are there not altered. This emphasizes the well-known fact that although a group of terranes may be highly altered in one locality, its extension may be made up of slightly altered rocks. The prospector should bear this fact in mind in seeking for new mining fields. So far as the evidence goes, the Porcupine basin does not seem a promising field for gold discoveries. On the other hand, the metamorphic rocks of Seward Peninsula probably find an extension east of the locality where they are indicated on the map. The metamorphic rocks of the inland zones are probably chiefly of Paleozoic age. Between the two general zones of metamorphic terranes there are some smaller belts of

highly altered rocks which locally have proved to be gold bearing. It is presumable that some of these will be found to cover larger areas than here indicated.

The experienced prospector need not be told that it does not follow that because a certain formation is gold bearing gold will be found wherever it occurs. A tyro, however, may interpret the accompanying map as an absolute indication of the distribution of gold rather than as a guide to localities where the precious metal is likely to be found. Although the laws governing the distribution of gold in this field are but imperfectly understood, it seems certain that the occurrence of mineralization is due to causes that have in many places acted very locally. There appear to be no facts which bear out the assumption often made that there are one or more well-defined gold belts which can be traced across Alaska, though the formations with which gold is associated may be found to be continuous over extensive areas. The work so far accomplished appears to justify the statement that within the areas of metamorphic rocks there are zones of mineralization. These are, however, usually of very slight extent, ranging from only a few hundred yards to rarely a few miles in length. There is but little information on which to formulate a law for the occurrence of these mineral zones, and it is quite possible that in the different districts different causes have been operative.

It appears to have been definitely established by Mr. Wright (see pp. 49–50) that in southeastern Alaska there is a causal relation between the intrusion of the Mesozoic granites and the ore bodies. As he sets forth, the zones of mineralization thus far discovered all occur along or near the margins of the intrusive granite masses. There is some evidence that a similar association of the zones of mineralization and the granite exists in the Yukon district. Prindle has shown that granitic rocks are common in all the gold-placer districts of the Yukon-Tanana region and that in at least one locality the gold is closely associated with intrusive phenomena. He has also suggested that intrusion and the formation of quartz veins took place at different periods.[a] During the last summer the writer found evidence of mineralization accompanied by deposition of gold in the so-called Aucella beds (lower Cretaceous) on Washington Creek, a tributary of the Yukon. This appears to be the first instance in this province where definite proof was obtained of a post-Paleozoic mineralization, and is significant because it appears to belong to the same period as the intrusion of auriferous veins in southeastern Alaska.

Mendenhall[b] has shown that in the Chistochina placer district of upper Copper River the mineralization is post-Permian and pre-Eocene,

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[a] Prindle, L. M., The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska: Bull. U. S. Geol. Survey No. 251, 1905, p. 37.

[b] Mendenhall, W. C., Geology of the central Copper River region: Prof. Paper U. S. Geol. Survey No. 41, 1905. p. 115.

so that it may be correlated with that on Washington Creek. Moreover, his geologic map shows the gold-bearing area to be intruded by many igneous rocks which are of the same general composition as the granites of southeastern Alaska. In other words, this occurrence appears to be closely analogous to the gold deposits of southeastern Alaska. Furthermore, some evidence is at hand which suggests a similar origin for the gold of the Susitna basin.

It is safe, therefore, to assert that the intrusion of the Mesozoic granite in many parts of Alaska was accompanied or followed by the formation of auriferous veins. It is important, therefore, to draw attention to the distribution of this rock. As shown by Mr. Wright, it not only forms the major portion of the Coast Range, but also finds a wide distribution in isolated stocks among the islands to the west. The main granite mass passes into Canadian territory in the Chilkat basin and has been traced northward to Kluane Lake, where, too, evidence of mineralization is found. It occurs again in the form of dikes and stocks along the northern margin of the Copper River valley and has been recognized at a number of places in the Alaska Range to the southwest.

The genetic relation of the auriferous deposits of Seward Peninsula is still an unsolved problem, but so far no connection with the granitic intrusions has been established. Mr. Moffit shows elsewhere in this report (see pp. 130–132) that the placer gold of the Nome region proper finds its source in a series of closely folded and faulted metamorphic rocks and apparently most commonly along the contact between the schists and crystalline limestones. The only ore deposits in this province which have been found in association with granite intrusions are the cassiterite lodes, which, as Collier[a] and Hess[b] have shown, are closely connected with the intrusions. The developments of the past year at Cape Mountain clearly show that the tin ores occur along the margins of the granite. It is unfortunate that little is known of the age of this granite. While it has generally been regarded as Paleozoic, it may be Mesozoic, but is certainly pre-Eocene.

The matter already presented refers chiefly to the auriferous veins, but is probably applicable to some of the copper deposits, especially in southeastern Alaska. In Prince William Sound[c] the copper deposits are intimately associated with greenstones and greenstone schists, probably of Mesozoic age, which are relatively little altered. Granite intrusions are present in this province, but the ore bodies are not known to have any genetic relation to them. The copper ores of Copper River occur as contact deposits along a semicrystalline lime-

[a] Collier, A. J., Tin deposits of the York region, Alaska: Bull. U. S. Geol. Survey No. 229, 1904; Recent development of Alaskan tin deposits: Bull. U. S. Geol. Survey No. 259, 1905, pp. 120–127.

[b] Hess, F. L., The York tin region: Bull. U. S. Geol. Survey No. 284, 1906, pp. 145–157.

[c] Grant, U. S., Copper and other mineral resources of Prince William Sound: Bull. U. S. Geol. Survey No. 284, 1906, pp. 78–87.

stone and a greenstone which is probably an ancient lava flow.[a] The foregoing statements indicate that some of the copper-bearing lodes of Alaska appear, in part, at least, to be the result of a different group of phenomena from those which caused the auriferous lodes.

LODE MINING.

INTRODUCTION.

The most notable advance in lode mining during 1906 was the development of the copper deposits of the Ketchikan district and of Prince William Sound. While steady progress has been made in the auriferous mines of the Juneau district there were no marked developments. Statistics are not yet available, but it is not probable that the output of gold from this district was notably greater than in 1905, nor have any important discoveries of new auriferous-lode districts been reported. In Seward Peninsula the one developed lode mine has continued to be a producer and there was a noteworthy activity in prospecting quartz veins, but here also no important discoveries have been reported. Statements are current that auriferous copper-bearing lodes have been found in the Kobuk Valley and in the Susitna basin, but the proof of their commercial value will have to await further investigations. The same holds true of the auriferous lodes reported from Kenai Peninsula and Kodiak and adjacent islands. The copper-bearing property in the Iliamna Lake region has received some attention, but the writer has scanty information regarding it. It is at least of interest in suggesting the occurrence of mineralization in this little-known field. Though auriferous veins have been found in the Yukon basin, nothing of commercial importance has so far been developed.

STATISTICS.

It is unfortunate that the statistical data are not all in hand yet and that therefore the production can be stated only in general terms. It is probable that the value of the gold production from siliceous ores for 1906 is about $3,450,000 and that the copper ores yielded about $100,000 in gold. The value of the silver from both classes of ore for 1906 is probably about $50,000. The copper production of 1906 is estimated to have been about 6,000,000 pounds, valued at about $1,100,000. It is estimated that thirteen gold and silver mines were on a productive basis in 1906, as compared with ten in 1905. Fourteen copper mines are believed to have been operated in 1906, as compared with eight in 1905. In addition to the productive mines many prospects were being developed, especially in the copper districts. It has been impossible to gather any complete data in regard to the

[a] Mendenhall, W. C., and Schrader, F. C., Mineral resources of the Wrangell region: Prof. Paper U. S. Geol. Survey No. 15, 1903.

number of placer mines, but it is fair to presume that they include at least 1,200 different operations. In the absence of accurate information about tonnage and values for 1906 it seems worth while to make the following quotation in relation to the production of 1905:

The tonnage of all the lode mines of Alaska in 1905 was 1,422,515 short tons, an increase of probably about 40,000 tons over 1904. Of siliceous ores 1,370,316 tons were mined, of which 1,296,271 tons must be credited to the three mines of the Treadwell group on Douglas Island, near Juneau, leaving only 74,045 tons as the product of the other gold-quartz mines. The average gold and silver value of all siliceous ores was $2.63 per ton. For the 74,045 tons of siliceous ores other than those from the Treadwell group it was $5.60. A total of 52,199 tons of copper ores contained an average of $1.66 per ton of gold and silver, and copper to the amount of 4.61 per cent. It should be stated that the values of the siliceous ores mined thus far lie almost altogether in the gold, the silver values being often less than 1 per cent of the total. The high percentage of copper is accounted for by the fact that the Prince William Sound mines, which contributed a large percentage of the total tonnage in 1905, have so far shipped only high-grade ores. The copper percentage of ores from the Prince William Sound mines is nearly twice that of ores from the mines of southeastern Alaska.[a]

It can be added that the tonnage and values in the siliceous ore were probably about the same in 1906 as in 1905. The copper ores in 1906, however, showed an increase of at least 20 per cent, but the values remained about the same.

LODE DISTRICTS.

The southeastern Alaska districts are fully treated in other pages of this report. Prince William Sound and Copper River were not visited by any member of the Survey and the following notes are compiled from various sources.

The copper mines and prospects of Prince William Sound thus far discovered all fall within a zone about 10 to 20 miles in width stretching northeastward from Latouche Island to Boulder and Galena bays on the mainland. An examination of the map (Pl. I, p. 22) shows that much of this zone is under the water of the sound. As Grant[b] has shown, the ore bodies, chiefly chalcopyrite, occur as a rule along shear zones in the greenstone.

Two mines, the Gladhaugh and Bonanza, made shipments of ore to the Tacoma smelter throughout the year, and several other properties undergoing development also made some production. In the Gladhaugh mine a sixth level at 600 feet depth is said to have been reached. Though only a few properties have reached a shipping stage, there are probably two score that have been prospected during the past year. Most of this work was done on Latouche and Knight islands and at Boulder, Landlocked, and Galena bays. It is estimated that from 100 to 200 men have been almost continuously

[a] Brooks, Alfred H., Mineral resources U. S. for 1905, U. S. Geol. Survey, 1906, p. 129.

[b] Grant, U. S., Copper and other mineral resources of Prince William Sound: Bull. U. S. Geol. Survey, No. 284, 1906, pp. 78-87.

employed in these operations. It seems probable that in 1907 the number of productive mines will be very much increased.

The two copper belts on the north and south sides of the Wrangell Mountains continue to be a field of much prospecting. Developments have been confined chiefly to the more accessible southern belt, which it is expected will be connected by railway with tide water in the next two years. This mineral belt has been carefully traced by prospectors and probably most of it has been preempted by this time. On most of these claims, however, assessment work alone has been done. There has been systematic development on a number of larger holdings, notably on the Hubbard-Elliot property near the west end of the range, and on the Bonanza near the east end. It is claimed that a depth of 200 feet has been reached on the Bonanza.

In the upper copper belt, stretching more or less brokenly from White River to the head of Tanana and Copper rivers, a score or more prospectors have been at work and several new discoveries are reported. Some of them are so close to the international boundary that until an accurate delineation of that line is made it will be uncertain on which side of it they lie. It is reported that native copper-bearing lodes have been found on Kletsan Creek and on Camp Creek. The other copper deposits of this region are chiefly sulphides.

The most important fact in regard to the development of these copper districts is the assurance of a railway from the coast. Although the location of the coastal terminal, if current reports are to be credited, is not yet definitely settled, it probably will be either Cordova Bay or Katalla, from which a railway will be extended up Copper River. Meanwhile steps have been taken to establish means of communication by small steamers which will run between the rapids of Copper River and will be provisionally connected by tramways.

YORK TIN REGION.

No member of the Geological Survey visited the tin district during 1906. Current reports indicate considerable progress in lode mining at Cape Mountain and prospecting at Lost River and at Brooks and Ear mountains. The Buck Creek tin placers also received attention, and some shipments of stream tin were made.

The margin of the granite mass of Cape Mountain, which appears to be the locus of the tin-bearing lodes, has been traced and entirely covered by locations, and considerable prospecting has also been done. During the last year cassiterite-bearing veins were found on the northwest side of the mountain, in the basin of Village Creek. The prospects are reported to be encouraging and at least are known to have the same general character as the better developed deposits on the southeast side of the mountain. By far the most extensive

operations of the district are those of the Bartels Tin Mining Company, on the southern slope of Cape Mountain. This company installed a 3-stamp mill in 1905, and some concentrates were shipped during the year. Current reports, which the writer is unable to verify, indicate that the ledge varies in thickness from 18 inches to several feet. Values of 1 to 55 per cent are reported, and the average of the ore mined is said to have been $3\frac{7}{8}$ per cent. The company is mining and also prospecting systematically with electric-power drills. An enlargement of the plant is said to be in contemplation. The United States-Alaska Tin Mining Company has erected a 10-stamp mill in the same region, but no shipments are reported. The Seward Tin Mining Company is said to be at work in the same vicinity, and some prospecting is reported on the Compass, Bear, Midnight, and Sun claims. The developments on the north side of Cape Mountain, at Village Creek, have already been referred to.

Less definite information is available concerning the operations at Ear Mountain and Lost River, but current reports indicate that systematic prospecting is still going on. The Lost River deposits are near the coast, but the Ear Mountain district is less accessible.

As no further studies have been made, it is impossible to present any conclusions in regard to the future of the district beyond those already advanced by Collier[a] and Hess.[b] The actual shipment of ore and the continuation of work in the various localities bear testimony of progress. There can be no doubt that this district has suffered by the exaggerated estimates of the tonnage of ore developed and its value, which have been published far and wide. While these are in part to be credited to conscienceless promoters, who are using tin prospects as a basis for the selling of stock, it is also due to the ignorance of honest prospectors. Nearly all the owners of tin prospects hold them at such enormous figures that the experts sent to examine them often must advise their clients against purchase. Those who are inexperienced in lode mining, especially of tin ores, should understand that capitalists will not pay for a prospect the same amount of money which they would for a developed mine. Had this fact been accepted by the prospectors, much more prospecting would no doubt by this time be carried on in this field by the moneyed interests.

In 1905 the average price of tin was 31.35 cents per pound; in 1906 it rose to 39.81 cents per pound. The world's production of tin in 1906 was 93,919 long tons, or about 500 tons less than in 1905. Of the total production about 47 per cent was used in the United States, with practically no production. These facts alone assure a continuation of the search for tin, especially in a field which has yielded as encouraging results as the York district.

[a] Collier, Arthur J., Tin deposits of the York region, Alaska: Bull. U. S. Geol. Survey No. 229, 1904.
[b] Hess, Frank L., The York tin region: Bull. U. S. Geol. Survey No. 284, 1906, pp. 145–157.

ANTIMONY.

Stibnite, the sulphide of antimony, has been found at a number of widely separated localities in Alaska, and in view of the constantly increasing demand for antimony it has seemed worth while to call the attention of prospectors to it. In 1906 the price of the metallic antimony increased from 14 and 15 cents to 25 and 26 cents a pound. The consumption of antimony in 1905 for the United States was 5,712 short tons, with no production except some recovered with lead ores. This fact has stimulated the search for commercial ore bodies containing the metal. Antimony finds its principal use in the manufacture of various alloys and in some chemical compounds.

Stibnite is a soft mineral, of a lead or steel-gray color, having a streak of similar color usually with a more or less perfect cleavage visible to the naked eye. This mineral is usually found in veins having a quartz gangue and associated with various other metals. The ore often contains some gold and silver. Of the valuation of the ores Schnatterbeck [a] makes the following statement:

> For the information of miners it may be said that smelters pay for ore according to its content of antimony (determined by a fire assay) and its freedom from impurities, such as arsenic, lead, and copper. Ores carrying less than 50 per cent metal are not marketable at present unless they have other unique features which would facilitate smelting. The smelter usually deducts about 30 cents per ton for sampling and weighing ore. In calculating the value of an ore the basis of quotations for metal in London is used, and should the ore exceed 50 per cent metal a premium is allowed, while for every per cent less a discount is exacted.

No ore bodies containing stibnite of proved economic importance have been found in Alaska. The ore is, however, known to occur at the localities mentioned in the following paragraphs:

Antimony ores have been reported from various localities in Seward Peninsula, but the only occurrence known to the writer is on Manila Creek and is described elsewhere in this report (p. 139).

Mr. Prindle reports the occurrence of stibnite in the placers of Cleary and Esther creeks, and he found it in place on Chatham Creek. At the latter locality [b] a vein a foot or more in thickness occurs in the schists.

In the Kantishna region Mr. Prindle found stibnite associated with the auriferous gravels on Eureka and Friday creeks, and in place on Caribou Creek. (See pp. 216, 219.)

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[a] Schnatterbeck, C. C., The production of antimony in 1905: Mineral Resources U. S. for 1905, U. S. Geol. Survey, 1906, p. 437.

[b] Bull. U. S. Geol. Survey No. 284, 1906, p. 114.

PLACER MINING.

INTRODUCTION.

Of the $21,600,000 worth of gold produced in Alaska in 1906, nearly $18,000,000 came from the placers, and more than half of this from the Fairbanks district. Seward Peninsula stands second, with a production of over $7,500,000, of which at least one-half came from the old beach line. The silver recovered from the placer gold represented in 1906 about two-thirds of the total output of that metal in Alaska, and had a value of about $60,000.

No new placer districts were discovered in 1906, but the Yentna, Kantishna, and Tenderfoot have become producers since last year. Mining in both Seward Peninsula and the Yukon district was more or less handicapped by the scarcity of water during a part of the open season.

METHODS.

The evolution of placer-mining methods, which is going on continuously, is directed chiefly toward the introduction of machinery in some form. As districts become more accessible the small operator is supplanted by companies with ample financial backing, to bring about a reduction of costs of operation. Moreover, the wasteful methods of the pioneer prospector can find no reward except in the richest and most favorably situated placers, and the gravels of lower value must await better capitalized companies. This change is taking place throughout Alaska, but notably in the Nome region. The most significant feature of this evolution during the last year was the systematic search for placer ground suitable for dredging.

Much has been written on the subject of dredging and its possible application as a mining method in this northern region. Though this is a matter for discussion by the mining engineer rather than by the geologist, a brief statement of a few conditions affecting dredging in this field may be of service to those who are not personally familiar with them. On the one hand, prominent mining engineers have been loud in proclaiming the inapplicability of dredging throughout most of Alaska because of the failure of certain misdirected efforts; on the other, less conscientious promotors have cited the low values profitably recovered by dredging in the Oroville (Cal.) and similar fields as examples of what may be accomplished in Alaska.

From the standpoint of dredging, the Territory may be divided into two provinces, one embracing the area tributary to the Pacific, and the other the placer districts of the Yukon and Seward Peninsula. In the Pacific province there are a number of placer districts which undoubtedly include some good dredging ground, yet in this part of Alaska glacial bowlders are not uncommon. Even in glaciated areas, where only easily decomposed rocks, such as mica schist, are present,

large bowlders may be exceptional. In general, however, bowlders must be expected, since glaciation has been an active agent throughout this province. As a rule the placers of this part of Alaska have not been found to be as rich as those of the Yukon and Seward Peninsula. On the other hand, frost is not encountered in the region tributary to the Pacific except in the Copper River basin and possibly in the upper basin of the Susitna. Other and very important factors in favor of the southern province are its accessibility, relatively cheap fuel, and abundance of water power. In the Yukon and Seward Peninsula districts glaciation is, for the most part, absent and bowlders are relatively rare. The values also average much higher, though these vary, of course, locally. Of fundamental importance for consideration in these fields is the large amount of frozen ground which can not be handled by a dredge unless previously thawed. The laws which govern the distribution of the ground ice are not known, so that each placer must be carefully tested on this point before a decision is reached. In general, however, it can be stated as an established fact that the river beds are not frozen, and also that any loose sand or gravel which is well drained is not frozen. The cost of fuel, transportation, and other factors which have been mentioned, vary in different districts of this northern province, but in general are higher than along the Pacific coast. Water power, too, is much rarer than in the southern field. In a comparison of the two provinces it is obvious that the southern field is one where bowlders are to be expected, while in the north the presence of frozen ground may so increase the cost of exploitation as to make it prohibitive.

It may be of value to present some facts on the costs and methods of dredging frozen ground, as determined in the Klondike. The writer is indebted to Mr. Albert J. Beaudette, government mining engineer of the Yukon Territory, for the following statement:

The dredge now operating on Bonanza Creek was erected on creek claim No. 42 below Discovery in the year 1901 and afterwards removed to where it is now, on Discovery claim, a distance of about 4 miles farther upstream. It is one of the old type of dredges manufactured in San Francisco, using steam as its motive power. This boat has a theoretical capacity of 1,200 cubic yards per twenty-four hours, but this year it has excavated on an average 700 cubic yards per twenty-four hours for a period of one hundred and twenty-seven days. The capacity of the buckets is 3¼ cubic feet, moving with a velocity of 14 to 16 buckets a minute. It requires 65 horsepower to run the dredge.

The great drawback in dredging operations is the "frost," which must be overcome at any cost before the gravel can be excavated and washed. As the plant on the dredge is too small to furnish steam for both the dredge and the points used for thawing, the management had to erect another plant near by to furnish steam for the points. This plant consists of two boilers of 50 horsepower each, 60 points, and pipes to transmit the steam from the boilers to the points at a distance of 25 to 100 feet from the boilers. The points used are from 14 to 16 feet in length and they will thaw the material to the bed rock.

The claims upon which the dredge is being operated have all been worked by the placer method, and it has been found that a great portion of the ground is already thawed and only places where the muck has not been removed are required to be thawed by steam. In the spring the thawing begins fully a month before the dredge is put into operation, and in that way there is always enough ground thawed ahead of the dredge to keep it in operation. The ground is 15 feet to bed rock, consisting nowhere of more than 4 feet of muck and the remainder gravel. The character of the bed rock changes many times in one cross section of the creek from very soft to very hard and slabby, which will affect the duty of the point. The amount of ground that can be thawed by each point varies from 5 to 8 cubic yards in twenty-four hours, according to the amount of muck and the depth to bed rock, the lowest average being 3 feet square of bed rock for a depth of 15 feet to each point.

I here give you concise data about the operations, together with the costs:

Wood used per twenty-four hours .... cords..	$5\frac{1}{2}$
Cost of wood per cord	$13.50
Labor, 2 shifts, 3 men each shift	$40.00
Cubic yards thawed per twenty-four hours	400
Cost per cubic yard for thawing .... cents..	28.5

The above is the expenditure for thawing alone, for which the plant cost about $4,000.

The figures above given are in a general way applicable to the inland placer districts of Alaska. Costs will, of course, vary according to locality. On Seward Peninsula the operating expenses, as well as the cost of installment of the plant, should be less than these figures.

The question of water supply for hydraulic-mining purposes is still of supreme importance in all the placer districts. At Nome and in other parts of Seward Peninsula the rapid extension of ditches will very soon drain all the streams available for use in hydraulic mining, and then placer-mining operations will cease to expand in this direction. With the cheaper fuel which is likely to come with the utilizing of water powers, other than hydraulic methods will undoubtedly be introduced. In the Yukon camps but little ditch building has taken place, and most of the mining work has been in rich ground, where hydraulic methods are not necessary for profitable exploitation. The deep-lying gravels of the Fairbanks district must always be mined by underground methods, and the only hope of material reduction in costs appears to be in lessening the expense of transportation.

PLACER MINING, BY DISTRICTS.

It is here proposed to summarize the mining developments in the regions which are not more fully treated in other parts of the report. As the following notes are only in part based on the observations of members of the Geological Survey, they must of necessity be ill balanced.

PACIFIC COAST REGION.

Mr. Wright treats of the placers of the Juneau, Porcupine, and Lituya Bay districts in this report (pp. 51, 55, 56, 64, 65). The most noteworthy fact is the small advance made in placer mining in the Porcupine field. An abundance of water and steep gradients, with considerable bodies of gravel, are the favorable conditions in this field, but, on the other hand, the district is handicapped by the ruggedness of the topography and the frequent floods, which often carry away the miners' equipment. The presence of glacial bowlders over much of this district is unfavorable to dredging operations. Although the values average much lower than in the Yukon and Seward placers, yet they are within the limits of profitable mining, provided the other difficulties can be overcome.

The beach placers at various places along the seaboard between Lituya Bay and Unga Island yield only a small annual production, but probably give employment every year to half a hundred men. These deposits are of such a character that they can not be mined on any but a small scale. All attempts so far made to exploit them with machinery have met with failure. Yaktag Beach, which is about 60 miles east of Controller Bay, is estimated to have produced about $25,000 in 1906. About $10,000 worth of gold has been taken from the beaches of Kodiak and the other islands lying to the southwest.

In the Copper River region the most active placer-mining operations were in the Nizina basin, tributary to the Chitina. This district lies about 200 miles by trail from tide water, and the cost of operations is necessarily very high. It is reported that five claims were operated in the summer of 1906, employing in the aggregate 30 men. In the Chistochina district no rapid progress is reported, but considerable mining was carried on.

The Cook Inlet placers are described elsewhere (pp. 115–124), and it is shown that there has been a decided falling off in output as compared with 1905. The one important advancement is the exploitation of the placers of the Yentna district. The value of the production for 1906 of Cook Inlet and Copper River is estimated to have been $400,000.

SEWARD PENINSULA.

The Nome district continues to be the mining center of Seward Peninsula, with the Council district as second. Of the production of $7,500,000 for the entire peninsula, probably 50 per cent must be credited to the third-beach placers near Nome. These two important districts, as well as the Kougarok, are described elsewhere in this report (pp. 126–181). In the lesser districts, such as the Bluestone

and Teller, some developments are being made, but they are entirely overshadowed by the other camps.

In the Fairhaven precinct notable advancements were made, chiefly in ditch building. The Fairhaven Water Company completed the construction of about 30 miles of ditch, which taps Imuruk Lake and which when completed will have a total length of 52 miles and will discharge at Washington Gulch, an easterly tributary of the Inmachuk. The ditch has a capacity of 5,700 miner's inches. A 4-mile ditch is being built at Hannum Creek. A number of surveys have been made, with a view of bringing water to Candle Creek, where the rich bench placers are being worked.

Dry weather prevailed in the Fairhaven district, as in other parts of of the peninsula, and hence the largest production was made during the winter months. Considerable gold was taken out of the benches of Candle Creek by winter drifting. The coal mine at Chicago Creek furnishes the fuel for these undertakings. Some rich placer ground was mined on Chicago Creek, and current reports indicate that one claim at this locality was the largest producer of the season. It is also stated on good authority that prospecting in the immediate vicinity of the ground failed to reveal any other workable deposits. Considerable winter work was done on the lower Inmachuk and its tributaries. It seems probable that the value of the production of this camp in 1906 was between $200,000 and $300,000, though by some it is stated as high as $500,000.

YUKON BASIN.

The enormous production of the Fairbanks district, which amounted to over $9,000,000, overshadowed all other developments in the Yukon basin. The smaller districts all made progress during the year. Of these the most accessible, such as the Rampart, and to a certain degree Birch Creek, naturally received the most attention.

FAIRBANKS.

It is estimated that between 5,000 and 6,000, people were in the Fairbanks district during the summer of 1906. Probably over 50 per cent of these left before the fall freeze-up. A large part of the influx was made up of people with little money or experience in mining, and naturally the expectations of many were doomed to disappointment.

In spite of the prosperous condition, the midsummer saw the camp crowded with men who could find nothing to do. While wages continued high, $5 to $6 a day with board, the character of most of the operations made it possible to employ but few inexperienced men. The depth of the alluvium, from 10 to 200 feet, makes prospecting exceedingly costly. Prospect shafts cost $6 to $8 a foot, and every pay streak that has been found represents an enormous outlay for

unsuccessful prospecting. Therefore the Fairbanks district proper is eminently not the place for prospectors of small means, but affords splendid opportunities for those with good financial backing. In adjacent areas, however, such as parts of the Tenderfoot district, where the alluvium is much shallower, there are much better chances for the individual miner. It must be remembered that these outlying districts are but little easier of access than they were a few years ago.

There was a great scarcity of water in the Fairbanks district up to the last week in August, after which time there was considerable rain. One of the most favorable features about the Fairbanks district is the fact that the work goes on throughout the year, thus giving steady employment to miners and assuring a more permanent population. In 1906 the summer production was probably not more than 50 per cent of the total.

Means of communication are being rapidly extended. Nearly all the large producing creeks are now connected by wagon roads, either with water transportation on the Tanana, or with the Tanana Mines Railway. This, together with the telegraph and telephone lines, much facilitates business.

Cleary, Fairbanks, Dome, Vault, Esther, Goldstream, and Pedro creeks and their tributaries are the chief producing creeks of the district. Cleary continues to stand first in production, with Fairbanks in second place. The finding of values on Cripple and Treasure creeks definitely extends the producing area to the southwest, and reported discoveries of gold in the upper Chena may show a northeasterly extension of the same belt, though this is not yet established.

The facts in hand are, however, sufficient to determine that there is a gold-bearing zone, at least 10 miles wide, running northeast and southwest, which has been traced for about 30 miles. Its northeastern extension would intersect the upper Chena basin, while to the southwest it runs out into Tolovana flats. A logical deduction from these facts would suggest that the prospector should turn his attention to the Chena basin and to the streams draining the upland which bounds the Tolovana flats on the east. It should be remembered however, that the investigations so far made indicate that the conditions which bring about mineralization are local, and hence the formation of placers probably does not persist over any great distance.

Worthy of special note are the rich placers found last year on Vault Creek, which had previously been unproductive. On nearly all the producing streams which are tributary to the Chatanika the pay streak has been traced well down to the main river. In fact, the origin of the rich gravels found in various places at 100 to 200 feet depth under the valley floor of the Chatanika is among the most puz-

zling of the phenomena connected with the placers of this district. Interest in Goldstream Creek was revived during last summer by some rich placer discoveries, and as a result, though the creek was almost abandoned in the early part of the summer, later it was studded with operators for several miles.

Mine operators are rapidly recognizing the necessity of making available all of the water supply tributary to the gold-bearing area. At best the water supply during dry weather is very scant and on some creeks is practically nil. Among the largest ditch-building schemes is that involving the construction of a water main from the upper drainage basins of the Chatanika, for which surveys have been made. It is estimated that this ditch, which is to bring the water of Faith, McManus, Pool, and Smith creeks to the Fairbanks-Cleary divide, will be 72 miles long. It is currently reported that the low-water discharge of these streams is about 5,000 miner's inches at the proposed intake, but these figures the writer has no means of verifying.

Of the outlying districts tributary to Fairbanks the Tenderfoot probably made the largest production, estimated at $100,000. The gravels on Tenderfoot Creek are deep, but in the smaller creeks are said not to exceed 8 to 10 feet in depth. It would appear that these deposits lie in a different zone from those of Fairbanks.

Some work was done on the streams tributary to the upper Chatanika, where probably 30 men were at work. Some gold has been found on Faith, Hope, and Homestake creeks. The pay streak is thin and the values are said to be regularly distributed.

The region lying south of Fairbanks, including the Bonnifield and Kantishna districts, is described by Mr. Prindle (pp. 205–221), and the Birch Creek district by the writer (pp. 187–204), elsewhere in this report.

RAMPART DISTRICT.

The total gold output of the Rampart district for 1906 is estimated to have a value of $270,000. The writer is indebted for valuable information to Messrs. H. F. Thumm and E. H. Chapman, of Rampart. Mr. Thumm states that about 33 claims were worked during the winter of 1906 and 17 during the summer, giving employment to about 100 men in winter and about twice as many in summer. New creeks not producing last year are Boothby and Skookum.

Three hydraulic plants were operated during part of the summer, one each on Hoosier, Ruby, and Hunter creeks. The Alaska Road Commission has begun the construction of a highway from Rampart up Big Minook. This when completed will materially reduce the cost of all mining operations.

Another road has been built from Baker Hot Springs to Glenn Creek, a distance of 24 miles, by Thomas Manley, a large owner of mining

property. This road affords a natural outlet to Tanana River for the Glenn Creek region. Mr. Manley has also surveyed a ditch line from Hutlinana Creek to Thanksgiving Creek, a distance of 15 miles. If the scheme is carried out and there is sufficient water it will lead to extensive mining developments in the Glenn Creek region. It is of interest to note that the same operator has imported a churn drill for prospecting, the first in the district.

KOYUKUK DISTRICT.

Little information is at hand regarding the remote Koyukuk district, but it is reported that the gold production in 1906 was about $150,000 or $200,000. There has been no reduction in cost of operations, and until such takes place there will probably be no expansion of the mining. It is said that there are about 200 men in the Koyukuk district, and that the richest placers are on Newlands Creek. During the past winter a stampede took place on Johns River, but it appears that nothing of value was found.

Late in the summer of 1906 a report came to Fairbanks of the discovery of new placer ground in the Chandlar basin. The Chandlar is tributary to the Yukon from the northwest about 20 miles below Fort Yukon. Auriferous gravels have long been known to occur in this region,[a] but no workable placers have previously been found. A stream called Big Creek is reported to be the scene of the new find.

FORTYMILE REGION.[b]

The area usually included under the name Fortymile region embraces the basin of Fortymile River as well as the placer district tributary to the town of Eagle. Though the oldest of the Yukon camps, progress has been very slow, chiefly because of the lack of transportation facilities. This is being remedied to a certain extent by the construction of a wagon road to Steele Creek.

Upward of 200 men are working in this district, probably on half as many claims. The principal producing creeks are Jack Wade, Chicken, and Lost Chicken, together with their tributaries. The producing creeks in the region tributary to Eagle include several confluent to Seventymile Creek, together with American Creek and some smaller streams.

Considerable interest has been taken in the Fortymile region in the subject of dredges, but no plants have yet been set up. There are also plans for ditch building, but these have not gone beyond preliminary surveys.

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[a] Schrader, F. C., Preliminary report on a reconnaissance along Chandlar and Koyukuk rivers: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 341-423.

[b] The writer is indebted to Messrs. Elmer R. Brady, commissioner at Jack Wade, and U. G. Myers, commissioner at Eagle, for information about the Fortymile region.

The writer is indebted to C. B. McDowell, of the Fortymile region, Alaska, for the following statement in regard to the developments in that district:

> As dredging has proved so successful in the Klondike, many efforts are being initiated here looking toward working this section in a similar manner. Russell King, of London, has purchased several miles of Walkers Fork and is now installing a 5-foot bucket dredge on the properties. He expects to begin operations in the early part of June. The McDowell-Allen Company is also installing a dipper dredge on South Fork of Fortymile River and likewise expects to begin operations early in the summer. A company installed a dredge on the Canadian side of Fortymile River late last summer and will work its ground in this fashion the coming summer. Another dredge is now being installed at the boundary on the Fortymile for operations this summer. G. L. Savage, of New York, began operations late last fall on a ditch line to carry water from Mosquito Fork into the Chicken Creek basin for hydraulic purposes. Considerable prospecting for quartz was carried on last year, and while there were two good surface showings found—one gold and one copper—sufficient work has not yet been done to demonstrate whether they are of any great value or not.

According to the statement of J. H. Van Zandt, deputy collector at Fortymile, 11,974 ounces of gold were shipped through his office in 1906. The entire production of this district in 1900 is estimated to have a value of $300,000.

MAP OF ALASKA, SHOWING DISTRIBUTION OF COAL AND COAL-BEARING ROCKS, SO FAR AS KNOWN.

are consequently not well defined and must be regarded as subject to considerable changes by subsequent exploration. They are intended to indicate the regions in which new discoveries of coal seem, in the light of our present knowledge, to be most probable. The extent of the various areas noted above, as well as the area of each individual coal field, is shown in the following table, which gives a total of at least 1,238 square miles, or 792,320 acres, of known workable coal and 12,644 square miles, or 8,092,160 acres, of "coal-bearing rocks."

Areas of Alaska coal fields.[a]

	Known coal areas.	Areas of coal-bearing rocks. [b]
	Square miles.	*Square miles.*
Anthracite:		
Bering River	26.4	....
Matanuska River	4.2	....
	30.6	....
Semibituminous:		
Bering River	20.2	620
Matanuska River	20.3	....
Cape Lisburne	14.2	....
	54.7	620
Bituminous:		
Matanuska River	22	900
Alaska Peninsula	69	657
Yukon basin	167	2,490
Cape Lisburne	205	1,255
Anaktuvuk River	9	68
	472	5,370
Total anthracite and bituminous	557.3	5,990
Lignite:		
Southeastern Alaska	10	50
Cook Inlet region	304	2,565
Southwestern Alaska	16	300
Copper River	....	20
Yukon basin	216	1,557
Bering Sea	52	426
Northern Alaska	83	1,736
	681	6,654
Grand total	1,238	12,644

[a] The differences between the areas given here and those published elsewhere are due chiefly to the recognition of four classes of coal instead of three, and the consequent division of the Lisburne areas into semibituminous and bituminous and of the Yukon areas into bituminous and lignite, and of similar changes in other smaller areas.

[b] See explanation on p. 40.

GEOLOGY OF THE COAL-BEARING ROCKS.

The geologic position of Alaska coals is distributed through horizons in the Carboniferous, the Jurassic, the Cretaceous, and the Tertiary. The abundance of the coal and the extent of the areas increase progressively from the older to the younger horizons, reaching their culmination not later than the Miocene.

It should be noted in this connection that the old belief that the age of coal is an index of its quality does not hold uniformly in Alaska or elsewhere. This belief contains a partial truth in Alaska as in other regions, but other factors are always locally of greater weight. The

Carboniferous coals of Alaska are of higher grade than those of the Jurassic or the Cretaceous, and the Jurassic coals are better than some of the Cretaceous coals. The Cretaceous in turn includes some coal which is of better quality than much of the Tertiary coal. Thus far it would seem as if the theory of the increase in quality of coal with its age were supported by the evidence from Alaska. But when the Tertiary coals are considered it is found that they include many beds and considerable areas which outrank in quality all the other coals of Alaska and which are equaled only at a few areas in other regions. The truth of the matter is that the conditions favorable for the formation of high-grade coal, including character of sedimentation and degree of alteration, are dependent on local conditions and are independent of the age of the coal.

Carboniferous coal is known to exist in commercial quantities at Cape Lisburne and smaller amounts are known at other localities. The Carboniferous coal beds at Cape Lisburne are in the lower Carboniferous, which there comprises a lower group consisting of slates, shales, and limestones and containing several coal beds; a middle group of black cherts, slates, shales, and cherty limestones; and an upper group of massive limestones of great thickness, which seem to shade off into massive white cherts. Coal beds of Permian age have been worked near Nation River on the upper Yukon, but they appear to be of slight extent and of little importance, although the quality is good. Rocks of probable Carboniferous or Permian age are known to contain coaly shales and thin coal seams at various localities in the valley of White River and indicate that workable coal beds may yet be discovered in them.

Jurassic rocks have a wide distribution in Alaska, and they are known to be coal bearing in several places. The largest known area of Jurassic coal is at Cape Lisburne, where a horizon of undetermined position in the Jurassic is represented. The Wainwright Inlet coal is probably of the same horizon. At least part of the coal at Herendeen Bay may be Jurassic, though other coal-bearing horizons are represented. The eastern extension of the Matanuska coal field includes large areas of middle and upper Jurassic rocks in which some coal is present.

Cretaceous rocks cover large and widely distributed areas in Alaska and are coal bearing at many localities. Cretaceous coal is present on Anaktuvuk River, a tributary of the Colville, which flows into the Arctic Ocean, in the lower Yukon Valley, possibly at the headwaters of the Matanuska, and at Chignik Bay and Herendeen Bay, in southwestern Alaska. All these deposits except that in the Matanuska Valley represent the upper Cretaceous.

Tertiary coal is widely distributed in Alaska, being known from many localities along the Pacific coast, from the interior, and from the Arctic slope. The position of the coal within the Tertiary is

rather indefinite, the evidence being incomplete and conflicting. The Tertiary coal-bearing rocks on the Yukon rest upon the Cretaceous with an apparent conformity, thus suggesting that the lower beds are basal Eocene or even transitional from the Mesozoic to the Cenozoic. Other evidence, including the relation of the floras of the Kenai formation to those of other regions and the relation of these beds to the overlying Miocene, indicates that the Kenai coal is upper Eocene or Oligocene. The coal floras on Bering River include forms suggesting those of the Kenai and other forms which are strangers to those beds and which Knowlton considers possibly Miocene. Still younger coal occurs at Yakutat Bay, where there are no rocks of Kenai age and where the floras belong very high in the Tertiary. The total evidence thus suggests that the Tertiary coal of Alaska occurs at several distinct horizons.

OCCURRENCE OF COAL.[a]

PACIFIC COAST REGION.

The Pacific coast coal fields are of moderate area but of wide distribution. They include both Mesozoic and Tertiary coals, with the complete range in composition from a good quality of anthracite, through high-grade semibituminous steam and coking coals and ordi-

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[a] The following references include the latest and most complete reports on each region. Earlier reports of importance, when referred to in later ones, are not mentioned here.

PACIFIC COAST REGION.

MARTIN, G. C., The distribution and character of Bering River coal: Bull. U. S. Geol. Survey No. 284, 1906, pp. 65–77.

——— A reconnaissance of the Matanuska coal field, Alaska, in 1905: Bull. U. S. Geol. Survey No. 289, 1906, 36 pp.

——— Geology and mineral resources of the Controller Bay region. (In preparation.)

PAIGE, SIDNEY, The Herendeen Bay coal field: Bull. U. S. Geol. Survey No. 284, 1906, pp. 101–106.

PAIGE, SIDNEY, and KNOPF, ADOLPH, A reconnaissance in the Matanuska and Talkeetna basins. (In this volume, pp. 104–115.)

STONE, R. W., Coal resources of southwestern Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 151–171.

——— Coal fields of the Kachemak Bay region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 53–73.

WRIGHT, C. W., A reconnaissance of Admiralty Island, Alaska: Bull. U. S. Geol. Survey No. 287, 1907, pp. 151–154.

INTERIOR REGION.

COLLIER, A. J., Coal resources of the Yukon basin, Alaska: Bull. U. S. Geol. Survey No. 218, 1903, 71 pp.

MENDENHALL, W. C., Geology of the central Copper River region, Alaska: Prof. Paper U. S. Geol. Survey No. 41, 1905, pp. 123–125.

PRINDLE, L. M., The Bonnifield and Kantishna regions. (In this volume, pp. 221–226.)

BERING SEA AND ARCTIC SLOPE.

BROOKS, A. H., Coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 515–571.

COLLIER, A. J., Geology and coal resources of the Cape Lisburne region: Bull. U. S. Geol. Survey No. 278, 1906, 54 pp.

MOFFIT, F. H., The Fairhaven gold placers, Seward Peninsula, Alaska: Bull. U. S. Geol. Survey No. 247, 1905, p. 67.

SCHRADER, F. C., Reconnaissance in northern Alaska across the Rocky Mountains, along Koyukuk, John, Anaktuvuk, and Colville rivers and the Arctic coast to Cape Lisburne, in 1901: Prof. Paper U. S. Geol. Survey No. 20, 1904, pp. 106–114.

nary bituminous coal, to lignites of various character. Many of the coal beds are of great thickness, especially where the coal is of high carbonization, but unfortunately the high grade of coal and the great thickness of the beds are as a rule accompanied by an irregularity of the geologic structure that is unfavorable to mining conditions. The Pacific coast coals are in general favorably situated for shipment, and in this respect, as in the character of some of the coal, offer possibilities for a larger, more regular, and wider market than any of the other Alaska coals.

INTERIOR REGION.

The interior region, which is here defined to include the valleys of Copper and Yukon rivers and their tributaries, contains Cretaceous bituminous coal on the lower Yukon and Tertiary lignite and subbituminous coal on the upper Yukon and in the Tanana, Koyukuk, and Copper river basins. None of this coal is suitable for export, but it may be of considerable importance as local fuel.

BERING SEA AND ARCTIC SLOPE.

The coal of the Bering Sea and Arctic slope region includes great range in geologic age and great variety in character. Coal is present in the Carboniferous, Jurassic, Cretaceous, and Tertiary. The Cape Lisburne coal includes Carboniferous semibituminous and Jurassic bituminous, and in the Colville basin Cretaceous bituminous coal and Tertiary lignite are present. The other coal, as far as is now known (except the Wainwright Inlet coal, which is Jurassic), is all lignite of Tertiary age.

It is not likely that any of this coal is of immediate value for other than local use. The high-grade coal at Cape Lisburne may find an extensive market at Nome, but the shipping problems are serious. The other coal is of such character that its market must be restricted to local regions in which the cost of better imported coal is high. It may be of extreme importance and of great value in local operations, but it is not good enough to ship very far from the mines.

CHARACTER OF THE COAL.

The character of the coal in the Alaska fields has been stated in the previously published descriptions of the various fields and has been referred to in the preceding pages. A detailed discussion of this subject is consequently not necessary here. The following table is a summary of all the analyses of Alaska coal which have been made for the Geological Survey, and shows approximately the character and value of the coal from the known areas:

Analyses of Alaska coal.

	District and kind of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.
	ANTHRACITE.						
1	Bering River, average of 7 analyses	7.88	6.15	78.23	7.74	1.30	12.86
2	Matanuska River, 1 sample	2.55	7.08	84.32	6.05	.57	11.90
	SEMIBITUMINOUS.						
3	Bering River, coking, average of 11 analyses	4.76	13.27	74.84	7.12	1.51	5.68
4	Cape Lisburne, average of 3 analyses	3.66	17.47	75.95	2.92	.96	4.46
5	Matanuska River, coking, average of 16 analyses	2.71	20.23	65.39	11.60	.57	3.23
	BITUMINOUS.						
6	Lower Yukon, average of 11 analyses	4.68	31.14	56.62	7.56	.48	1.90
	SUB-BITUMINOUS.						
7	Matanuska River, average of 4 analyses	6.56	35.43	49.44	8.57	.37	1.40
8	Koyukuk River, 1 sample	4.47	34.32	48.26	12.95	....	1.40
9	Nation River, 1 sample	1.39	40.02	55.55	3.04	2.98	1.39
10	Alaska Peninsula, average of 5 analyses	2.34	38.68	49.75	9.22	1.07	1.30
11	Cape Lisburne, average of 11 analyses	9.35	38.01	47.19	5.45	.35	1.24
12	Anaktuvuk River, 1 sample	6.85	36.39	43.38	13.38	.54	1.20
	LIGNITE.						
13	Port Graham, 1 sample	16.87	37.48	39.12	6.53	.39	1.04
14	Southeastern Alaska, average of 5 samples	1.97	37.84	35.18	24.23	.57	1.02
15	Wainwright Inlet, 1 sample	10.65	42.99	42.94	3.42	.62	1.00
16	Colville River, 1 sample	11.50	30.33	30.27	27.90	.50	1.00
17	Upper Yukon, Canadian, average of 13 analyses	13.08	39.88	39.28	7.72	1.26	.99
18	Upper Yukon, Circle province, average of 3 analyses	10.45	41.81	40.49	7.27	1.30	.97
19	Upper Yukon, Rampart province, average of 6 analyses	11.42	41.15	36.95	10.48	.33	.91
20	Seward Peninsula, 1 sample	24.92	38.15	33.58	3.35	.68	.88
21	Chitistone River, 1 sample	1.65	51.50	40.75	6.10	....	.79
22	Kachemak Bay, average of 6 analyses	19.85	40.48	30.99	8.68	.35	.77
23	Cantwell River, 1 sample	13.02	48.81	32.40	5.77	.16	.66
24	Kodiak Island, 1 sample	12.31	51.48	33.80	2.41	.17	.66
25	Unga Island, average of 2 analyses	10.92	53.36	28.25	7.47	1.36	.62
26	Tyonek, average of 4 analyses	8.35	54.20	30.92	6.53	.38	.58
27	Chistochina River, 1 sample	15.91	60.35	19.46	4.28	....	.32

1. Bull. U. S. Geol. Survey No. 284, p. 74, analyses 1 to 7.
2. Bull. U. S. Geol. Survey No. 284, p. 98, analysis 1.
3. Bull. U. S. Geol. Survey No. 284, p. 74, analyses 10 to 20.
4. Bull. U. S. Geol. Survey No. 278, p. 47, analyses 13 to 15.
5. Bull. U. S. Geol. Survey No. 284, p. 98, analyses 2 to 17.
6. Bull. U. S. Geol. Survey No. 218, pp. 62, 63, analyses 26, 28 to 38.
7. Bull. U. S. Geol. Survey No. 284, p. 98, analyses 18 to 21.
8. Bull. U. S. Geol. Survey No. 218, p. 62, analysis 28.
9. Bull. U. S. Geol. Survey No. 218, p. 62, analysis 17.
10. Bull. U. S. Geol. Survey No. 284, p. 27.
11. Bull. U. S. Geol. Survey No. 278, p. 47, analyses 1 to 7, 9 to 12.
12. Prof. Paper U. S. Geol. Survey No. 20, p. 114, analysis 607.
13. Bull. U. S. Geol. Survey No. 259, p. 170.
14. Bull. U. S. Geol. Survey No. 284, p. 27.
15. Prof. Paper U. S. Geol. Survey No. 20, p. 114, analysis 653.
16. Prof. Paper U. S. Geol. Survey No. 20, p. 114, analysis 620.
17. Bull. U. S. Geol. Survey No. 218, pp. 61, 62, analyses 3 to 15.
18. Bull. U. S. Geol. Survey No. 218, p. 62, analyses 16, 18, 19.
19. Bull. U. S. Geol. Survey No. 218, p. 62, analyses 20 to 25.
20. Bull. U. S. Geol. Survey No. 247, p. 67.
21. Prof. Paper U. S. Geol. Survey No. 41, p. 125.
22. Bull. U. S. Geol. Survey No. 259, p. 170, analyses 3, 4, 7 to 10.
23. Bull. U. S. Geol. Survey No. 218, p. 62.
24. Bull. U. S. Geol. Survey No. 259, p. 170.
25. Bull. U. S. Geol. Survey No. 259, p. 170.
26. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, p. 23, analyses 1 to 4.
27. Prof. Paper U. S. Geol. Survey No. 41, p. 124.

DEVELOPMENTS AND PRODUCTION.

The coal-mining industry of Alaska is still in a practically undeveloped condition. Coal has been mined intermittently and on a small scale at several places for many years, but the industry has never been

of much importance. This has been because the better coal has not been well known until recently and can not be shipped without railway connections from the mines to tide water, and also because no adequate provision has been made for granting title to sufficient tracts to assure profits on the large investments which are required.

The most active mining operations have been on Cook Inlet, in southwestern Alaska, on the Yukon, in Seward Peninsula, and at Cape Lisburne. All of these were for the purposes of local fuel on small coastwise or river steamers, at mining camps, and at canneries.

The amount and value of the coal produced in the last ten years are stated in the following table:

Production of coal in Alaska, 1897–1906.[a]

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1897	2,000	$28,000	1902	2,212	$19,048
1898	1,000	14,000	1903	747	6,582
1899	1,200	16,800	1904	694	1,725
1900	1,200	16,800	1905	3,774	13,250
1901	1,300	15,600	1906	6,000	20,000

[a] The production for 1897, 1898, and 1906 is estimated. That for the other years is according to returns from the operators as published in Mineral Resources of the United States. These figures are known in some cases to be considerably below the true production, several operators not having reported at all.

The most important developments which are now going on are preparatory to mining the high-grade Matanuska and Bering River coal on a large scale for shipment away from the coal fields. These coals are adapted to use[a] on ocean steamers and railways and for the manufacture of coke, and for other purposes for which high-grade coal is required. Before they can be mined it will be necessary to build about 150 miles of railroad[b] to reach the Matanuska coal, and from 25 to 100 miles (according to the harbor chosen) to reach the Bering River coal. It is believed that either of these projects is legitimate, and that if favorable title can be obtained both fields will be producing on a large scale within a few years. Railroads are now under construction to both these fields.

The coal of the interior and northern parts of Alaska will probably be dependent on local demands[a] for its market as long as better coal remains nearer the seaboard. These local markets will depend chiefly on mining camps and will be transient or permanent according to whether the mining camps are placer or lode. Such coal fields of the interior as may be on the line of railroads or near lode mines, especially if the ores are smelting ores and the coal capable of coking, will attain considerable importance, but these conditions are contingent on future discoveries and developments which can not be foretold.

[a] Martin, G. C., Markets for Alaska coal: Bull. U. S. Geol. Survey No. 284, 1906, pp. 18–29.

[b] Brooks, A. H., Railway routes: Bull. U. S. Geol. Survey No. 284, 1906, pp. 10–17.

LODE MINING IN SOUTHEASTERN ALASKA.

By Charles W. Wright.

INTRODUCTION.

The results of the developments in the lode mines of southeastern Alaska during the year have been encouraging. Many of the prospects have grown into metal producers, and the mines have with but few exceptions increased their output. The Ketchikan district, the most active in these advances, is now an established mining center. In the Juneau district considerable progress has been made, though much looked-for development did not materialize. Mining interest in the Sitka district was renewed by the discoveries and successful explorations near Cape Edward, on Chichagof Island, but no important mine improvements are to be noted in either the Wrangell or Skagway districts.

The investigations of each successive field season bring forth new facts bearing on the geologic as well as the economic conditions in the southeastern portion of Alaska. Although much of the information contained in the present report has already been published,[a] it is, nevertheless, advisable to repeat the general facts so as to combine with them the results of the present year. In this manner the important conclusions are presented without delay, and the more detailed discussions of the geology and mines are given in the separate reports[b] on each district.

GEOLOGY.

Only those few geologic facts can here be given which are necessary to an intelligent description of the mines and which may also serve in some degree to guide the prospector in his search for new ore bodies.

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[a] Wright, F. E. and C. W., Economic developments in southeastern Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 47–68; Lode mining in southeastern Alaska: Bull. U. S. Geol. Survey No. 284, 1906, pp. 30–54.

[b] Spencer, A. C., The Juneau gold belt; Wright, C. W., A reconnaissance of Admiralty Island: Bull. U. S. Geol. Survey No. 287, 1906. Brooks, A. H., Preliminary report on the Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902. Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts (in preparation).

BEDDED ROCKS.

Limestone, slate, sandstone, and conglomerate, with intercalated greenstone and tuff beds, constitute the stratified rocks. In most places these have been profoundly metamorphosed and are represented by the crystalline limestones, mica and chlorite schists, cherts, and graywackes.

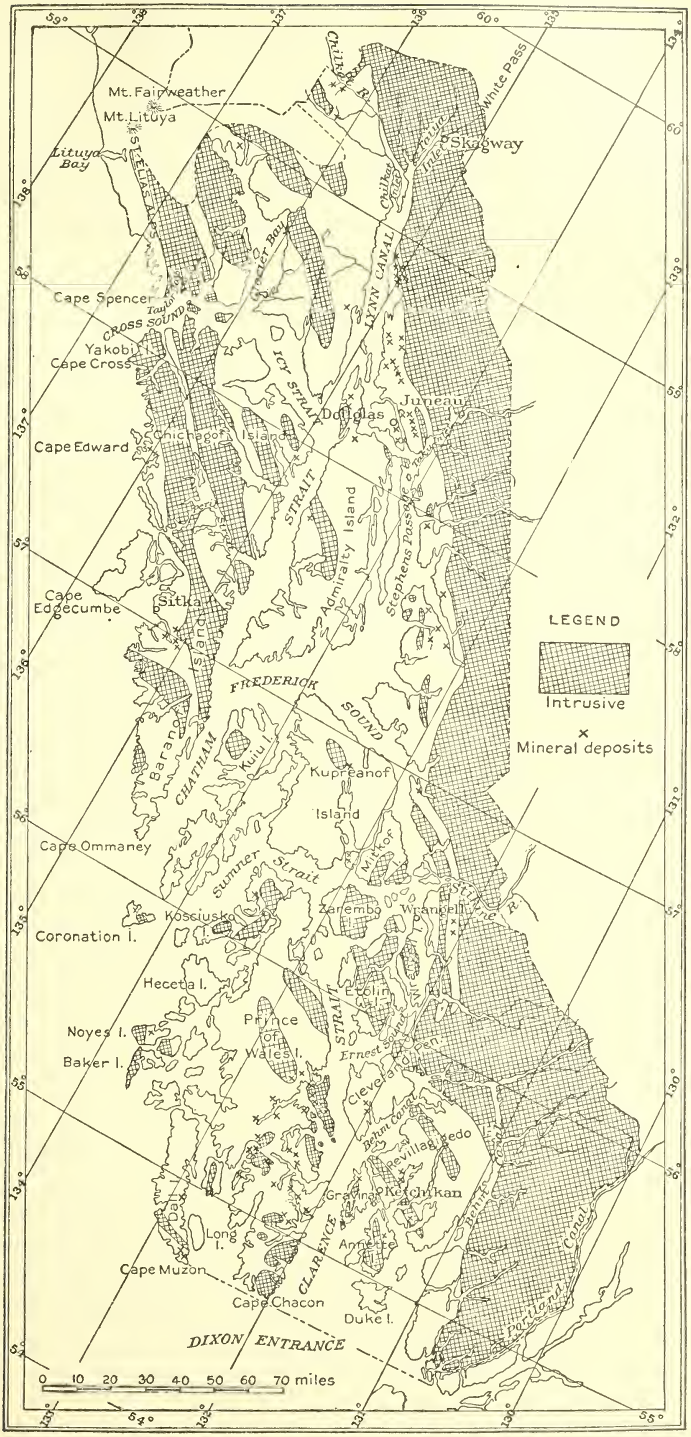
By far the greater portion of the rock strata are of Paleozoic age. These consist of the metamorphic limestones, schists, cherts, greenstones, and other rock types, which together form the underlying bedded rocks of the entire area. The Mesozoic and Tertiary formations are represented by the unmetamorphosed conglomerate, sandstone, and shale beds, which in places are coal bearing. They are only local in occurrence and of no great extent, occupying limited areas on Admiralty, Kupreanof, Kuiu, and Prince of Wales islands. Basaltic lava flows of late Tertiary age cover the southern portion of Admiralty Island, the northeast side of Kuiu Island, the south shore of Kupreanof Island, and a small area on the south end of Prince of Wales Island. Overlying these rock strata are beds of clay and gravel and the recent volcanics at Mount Edgecumbe and at points along the mainland.

INTRUSIVE ROCKS.

The intrusive rocks occupy about one-half of the aggregate land area of southeastern Alaska, as is well shown on the accompanying map (Pl. III). Coarse granular rocks, granitic in character, form the great mass of the Coast Range bordering the mainland and occupy wide areas in the central portion of many of the islands. They are in direct relation to the geologic structure, and their longitudinal axes and lines of contact parallel the direction of strike of the bedded rocks. Such intrusives vary in composition from granodiorite to quartz diorite and hornblende diorite. In general they invade the Paleozoic bedded rocks, but do not cut the more recent Mesozoic beds. Other intrusives are those of andesite, diabase, basalt, and melaphyr, usually in the form of dikes cutting both the older and younger sedimentary rocks.

STRUCTURE.

The sedimentary formations distributed along the mainland strip and adjacent islands all strike northwest and dip, as a rule, steeply to the northeast. The structure of the outer islands includes two separate systems of large and small folds. The main system, which is the younger of the two, has a northwesterly axial trend and is most pronounced adjacent to the wide areas of the intrusive rocks—namely, along the mainland and on Chichagof and Baranof islands. The minor system, which in most places has been obliterated by the



MAP OF SOUTHEASTERN ALASKA, SHOWING DISTRIBUTION OF MINERAL DEPOSITS AND AREAS OF INTRUSIVE ROCKS.

later and more intense folding of the beds, has a northeasterly axial trend and is prominent in the less disturbed and less metamorphosed areas. In many places both directions of folding are observed, those having the northeasterly trend being represented by a number of minor folds, which as a whole are combined in much broader anticlines or synclines having a northwesterly trend. Observations of this sort were made along the north shore of Chichagof Island and the west coast of Prince of Wales Island.

MINERALIZATION.

The direct relation of mineralization, or the occurrence of ore, to the rock structure and to the intrusive rocks is very evident. Without exception the ore bodies are found in the vicinity of, or more rarely in, the larger intrusive masses, and only in those places where the rock structure in general has a northwesterly trend. In a broad way the mineralization is confined within contact aureoles of the granitic and metamorphic rocks. Along the main Coast Range granite belt this contact zone is several miles in width, whereas along the outlying granite belts of the islands it is but a few miles wide. The larger areas occupied by this intrusive rock, so far as known, are shown on the sketch map (Pl. III), and the positions of the mines and prospects are indicated by crosses.

The most extensive and productive area is the Juneau gold belt, which has been irregularly traced along the contact of the Coast Range intrusive from Windham Bay to a point 10 miles north of Berners Bay, where it enters Lynn Canal, a total length of 120 miles and a width of less than 10 miles.[a]

The Admiralty Island mineral zone starts at a point just north of Mole Harbor on the west side of Seymour Canal and may be traced northwestward. It includes the Young Bay and Funter Bay deposits, crosses Lynn Canal, and is again exposed in St. James Bay and above the main forks of Endicott River. Mining and prospecting within this zone have been extensive but have met with little success.[b]

In the Sitka mining district a mineral zone begins on the southeast shore of Baranof Island and follows in a northwesterly direction along the west flank of a large granitic belt which forms the backbone of Chichagof and Baranof islands. Five miles above Cape Edward this belt enters the Pacific Ocean. Within this mineral zone the important deposits are quartz veins of free-milling gold ore. Several such veins in the Silver Bay region have been mined and have been productive in past years, and at the present time the Cape Edward prospects are making small shipments of gold ore.

[a] Spencer, A. C., The Juneau gold belt: Bull. U. S. Geol. Survey No. 287, 1906.

[b] Wright, C. W., A reconnaissance of Admiralty Island: Bull. U. S. Geol. Survey No. 287, 1906, pp. 138-155.

A second, less important zone of mineralization follows the east flank of the granitic belt already mentioned, though in this zone no ore bodies of consequence have been developed. The belt includes several prospects at the head of Hooniah Sound and Idaho Inlet. A northern continuation of this zone appears to traverse the head of the several bays northwest of Cape Spencer as far as Lituya Bay.

On Kupreanof Island are scattered indications of a widespread mineral-bearing zone, which extends from the head of Portage Bay down the east side of Duncan Canal and includes prospects along the west shore of Wrangell Narrows. The ore bodies thus far opened carry small values in both copper and gold. No deposits of ore have yet been discovered on Kuiu Island.

On Prince of Wales Island the regularity of the rock structure is locally interrupted by the broad and irregular intrusive masses, and for this reason the ore bodies are not traceable along definite lines. Where zones of mineralization occur they follow the lines of contact of the intrusive rock masses closely, as is well shown, for example, at Copper Mountain and on Kasaan Peninsula.

ORE BODIES.

Within the zones described above mineralization is widespread, metallic sulphides occur disseminated throughout most of the beds, and quartz veins or veinlets are everywhere present. A sample taken almost anywhere within such areas will usually yield a trace of gold and silver, though concentrations of these metals into workable deposits are much less numerous than one would anticipate with the vast amount of mineralization present.

The ore bodies are of many types. Strong gold-bearing quartz veins of moderate-grade ore, occurring either in the intrusive rocks or adjacent metamorphic rocks, are mined at Berners Bay, Eagle River, and Sheep Creek, in the Juneau district; on the west coast of Chichagof Island, north of Sitka; at Helm Bay and Dolomi near Ketchikan; and at many other localities. Lodes or stringer leads in the slates and schists or following wide dikes of a mineralized basic rock are most strongly developed up Gold Creek in the vicinity of Juneau and at numerous other points along the mainland belt.

Bands of heavily mineralized schist following the trend of the rock structure and cut by rich ore seams are shown at the Nevada Creek mines on Douglas Island, the Gold Stream mine on Gravina Island, and at other localities. The ore bodies of the Treadwell group of mines, as shown by Becker[a] and Spencer,[b] are brecciated masses of intrusive syenite, intersected by a network of quartz and calcite veinlets and impregnated with pyrite, which is found both in the veinlets

[a] Becker, G. F., Reconnaissance of the gold fields of southern Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 1-86.

[b] Spencer, A. C., The Juneau gold belt: Bull. U. S. Geol. Survey No. 287, 1906, pp. 93-115.

and in the rock itself. The ore bodies are several hundred feet in width and several thousand feet in length. No similar deposits have been discovered elsewhere in Alaska.

The copper deposits prominent on Prince of Wales Island can not be classed under the above-mentioned forms of occurrence. They are, with few exceptions, irregular lenses or masses of chalcopyrite ore, many of them rich in magnetite, and occur either as replacement or contact deposits adjacent to a granitic intrusive mass, and more rarely as heavily impregnated portions of schists.

GOLD.

OCCURRENCE.

Although gold is universally distributed along the coastal mountains of southeastern Alaska in lodes, and less commonly in placer deposits, there are relatively few localities which show a sufficient concentration of auriferous minerals to make valuable ore bodies, and in these places the ore is usually low in grade. The possibility of mining such ores, however, is obvious when one considers the available water power and favorable means of transportation the country affords. In the gold-quartz veins or lodes the gold is found both in the native state and also combined with metallic sulphides, which usually penetrate into the inclosing country rock. These quartz-filled fissures were formed subsequent to the general metamorphism of the coastal mountain range and after the granodioritic invasion, and their content is in genetic relation to the intrusive rock.

PRODUCTION.

The subjoined table shows the gold produced in southeastern Alaska in 1905. The placer deposits yield but a very small proportion of the gold production, their total output in 1906 being less than $20,000. Placer mining was advanced at only two localities, in Silverbow Basin and at Windfall Creek.

Production of the gold mines in southeastern Alaska, 1905.

Ore mined.	Gold.		Silver.		Average per ton.			
					Gold.		Silver.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
Tons.	*Ounces.*		*Ounces.*		*Ounces.*		*Ounces.*	
1,365,316	162,353	$3,335,466	31,110	$18,789	0.118	$2.44	0.023	$0.014

To the above figures must be added the gold produced from the copper mines, which amounted to $71,170 in gold and $16,021 in silver. It should also be stated that nine-tenths of the total output was from the Treadwell group of mines on Douglas Island.

The gold production for 1906 will slightly exceed that for 1905.

JUNEAU MINING DISTRICT.[a]

Those mines which were operated during the year in the Juneau district have, with hardly an exception, given satisfactory returns, though many of the new and extensive developments that were planned failed of accomplishment. Two large stamp mills, at the head of Gold Creek and on Nevada Creek, were built, and the capacity of some of the power plants and mills at present in operation was increased.

MINES OF DOUGLAS ISLAND.

Douglas Island, though small, has become widely known as the locality of the Treadwell group of mines. The geologic features of the Treadwell deposits and the methods of mining employed have been discussed in detail by Spencer[b] and by Kinzie.[c]

At the Alaska-Treadwell mine the shaft has now reached a depth of 1,500 feet, and from it the 1,450-foot level is being opened. Other developments have been confined to the 1,050-foot and 1,250-foot levels. There is apparently little change in the character and value of the ore with increasing depth. On the surface the Glory Hole, or open-pit workings, have reached the 330-foot level below the adit tunnel, and the ore is being mined close up to the walls. The open-pit method of mining will not be carried below this level. Most of the ore milled has come from the stopes on the 600-foot, 750-foot, 900-foot, and 1,050-foot levels. The annual report for the year ending May 31, 1906, states that a total of 888,411 tons of ore was milled during the year, yielding $1,902,455, or $1.07 per ton in bullion and $1.07 per ton in concentrates. The mining and development expense was $0.84 per ton, and the cost of milling $0.15 per ton. For the shipping and treatment of concentrates $0.12 per ton is to be added, and this with minor expenses makes the total operating cost $1.19 per ton of ore milled.

On the Seven Hundred Foot fraction operations were renewed this year and considerable ore was mined from the 660-foot level. On the 770- and 880-foot levels developments were advanced and some ore was mined. The lowest, or 990-foot, level was opened and the sample returns were reported to be encouraging.

The Mexican mine is now developing its 880-foot, 990-foot, and 1,100-foot levels. The ore mined has been mainly from the 550-foot

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[a] As the detailed report by A. C. Spencer on the Juneau gold belt (Bull. U. S. Geol. Survey No. 287) has recently been published, only brief mention will be made of the late improvements on the mines within this area.

[b] Op. cit.

[c] Kinzie, R. A., The Treadwell group of mines, Alaska: Trans. Am. Inst. Min. Eng., vol. 34, 1904, pp. 334-386.

and 660-foot levels, and to some extent from the 770-foot and 880-foot levels. The last annual report gave a total of 233,985 tons ore milled to January 1, 1906, yielding $703,765, or an average of $3.01 per ton.

At the Ready Bullion mine the inclined shaft has been sunk to the 1,500-foot level and developments furthered on the 1,350-foot and 1,200-foot levels. The ore mined was principally from the 750-foot and 1,025-foot levels. The yearly report to January 1, 1906, gave a total tonnage of 233,480 tons, yielding $439,815.

The power plants that operate this group of mines have undergone many interesting changes within the last year. The supply of water power has been increased by the building of a new dam at the headwaters of Fish Creek, thus forming a storage basin which will increase the supply by 200 miner's inches during the two months of low water in the winter. This will increase the amount of all ore milled by water power from 87 per cent to 93 per cent. Another large saving is to be made by the use of oil in place of coal, thus doing away with a large expense in the handling of coal and a reduction in the initial cost. For this purpose large supply tanks are being installed, pipe lines laid, and oil burners introduced in the boilers.

The Nevada Creek mine, belonging to the Alaska Treasure Consolidated Mines Company, on the southeast end of Douglas Island, has been energetically developed this year, both underground and with reference to surface improvements. The mine is located 1 mile from tide water, at an elevation of 825 feet. At this point a tunnel 700 feet in length has been driven in a southwesterly direction, nearly at right angles to the trend of the rock structure. Drifts 100 to 300 feet in length have been extended to the northwest and southeast from points 450 and 550 feet from the mouth of the tunnel, and from these other exploratory crosscuts have been driven. The country rock is essentially greenstone and greenstone schist, with intercalated bands of graphitic slate. The ore bodies may be defined as narrow bands parallel with the rock structure within which a concentration of metallic minerals has taken place. The ore minerals, essentially auriferous pyrite with sulphides of copper, lead, and zinc, are accompanied by both quartz and calcite veinlets. Intruding these rock beds are narrow dikes of basalt, striking in a northwesterly direction, which appear to have little effect on the ore occurrence. A change in the structural trend or a wrinkling of the schistose beds is indicative of an ore body. At such a place, 450 feet from the mouth of the tunnel, an ore body 10 feet wide and containing a narrow seam of high-grade quartz ore 2 to 12 inches wide is being opened. The values in this body appear to be limited to a distance of 100 feet along its strike, and the rock structure indicates that the deposit is in the form of a shoot pitching at an angle of 40° in a northwesterly direction and parallel

with the axis of minor folding or wrinkling. The present underground developments are confined to the exploration of this ore body.

From tide water to the mine a cable tramway 1 mile in length has been built. Just below the main tunnel a 20-stamp mill has been erected and was to be in operation by the end of 1906. For power purposes a 450-foot flume, with intake at 1,050 feet elevation on Nevada Creek, is connected by a pipe line 925 feet long with the compressor plant and mill at 750 feet elevation.

The operations on the Red Diamond group at the head of Nevada Creek, which were started the year previous, were discontinued early in 1906. On the Mammoth group and other adjacent properties assessment work alone was done.

The properties of the Alaska Atlin Mining Company, the Yakamaw Mining Company, the Alaska Consolidated Mining Company, and others located on the island have been idle for several years, and no improvements of consequence have been made on them.

GOLD CREEK MINES.

The proposed mining improvements on the lode system which is strongly developed within the Gold Creek drainage and extends over the Sheep Creek divide were not accomplished, and progress in actual mining over the preceding year has been slight.

Briefly, the deposits are of low-grade, free-milling ore and occur within an 800-foot belt of black slate which has been intruded by numerous dikes 10 to 50 feet in width of a dark-brown, altered basic rock, probably a gabbro. Numerous quartz gash veins are present within this belt, cutting both bedded and intrusive rocks, but are most plentiful near their contact. The auriferous sulphides, essentially pyrrhotite and pyrite, impregnate both the black slate and dike rocks, but the values are principally in the quartz veins. The average value of the ore mined in a large way is very low, and this has to some extent discouraged the investments of capital necessary for their economic development. It has, however, been demonstrated at both the Ebner and Alaska-Juneau mines that the ore can be profitably mined. This, with the undoubted persistence of mineralization and values in the lode system to a depth below which mining will likely go should tend to encourage mining operations.

Operations at the Ebner mine were continuous during the year, and results similar to those of former years were attained. In the upper tunnel the drifts were extended 350 feet, and in the lower tunnel 150 feet of drifting was done. During the year the 15-stamp mill on the property was in continuous operation except for a few weeks in the winter. The water power of Gold Creek at this point was sufficient to develop 125 horsepower throughout this period.

At the Alaska-Juneau mine operations were renewed in May and continued until November, as in previous years. During this time the 30-stamp mill was in continuous operation, an average of 4,200 tons of rock being milled per month. The ore mined was mainly from the open cuts and raises which were driven to open the back pits at lower levels.

At the Perseverance mine the greater portion of the work done was in the erection of a 100-stamp mill, which is to begin operations early in 1907. In the mine developments have been confined to an ore body 60 to 80 feet wide, consisting of a heavily mineralized black slate, cut by numerous quartz veins carrying pyrrhotite, chalcopyrite, galena, and sphalerite. This lode has a general northwesterly strike and dips 65° NE. At the time of the writer's visit it was exposed by a drift 1,000 feet in length at tunnel level and partially by a raise 920 feet long from the tunnel to the surface. From this raise 100 feet above the tunnel an intermediate drift, 350 feet long, has been driven in both directions along the lode and connected by raises with the tunnel drift. Other levels at intervals of 100 feet will be started from this main raise.

On the Boston group of claims, at the mouth of Gold Creek, a mineralized dike 50 feet wide is exposed similar to those found at the Ebner mine. This dike as a whole forms a very low-grade ore, and as yet no attempt has been made to begin its extraction in large quantities. The annual assessment work has been accomplished from year to year, and the present developments consist of a shaft 118 feet deep, from which 500 feet of drifting and crosscutting have been extended.

No improvements worthy of note were made on any of the other lode mines or prospects within the Gold Creek or Sheep Creek drainage areas last year.

The placer deposits of Silverbow Basin were again leased by the Silver Bow Hydraulic Company, and operations began the latter part of April and closed the latter part of October. During September work was suspended because of low water. The gravels were worked by a hydraulic giant having a 6-inch nozzle, and bowlders were handled by a cable with boat attachment. The gravel bank under attack is 75 feet high and in it the highest values are found where the oxidized sand streaks are present.

At the lower basin, on the property of the Jualpa Mining Company, no attempt was made to mine the gravels.

MINES NORTH OF JUNEAU.

SALMON CREEK.

At the mouth of Salmon Creek, the first stream north of Juneau, is the Wagner group of claims, located on a mineralized basic dike from 8 to 12 feet wide, cut by numerous quartz veinlets. This corresponds in character to the exposures on the Boston group mentioned above and lies in the same line of strike. Three other similar dikes were observed outcropping at different elevations on the mountain slope above. A total of 675 feet of tunneling has been driven 250 feet along the vein and 425 feet crosscutting the country rock. A small 2-stamp mill has been installed for test purposes.

MONTANA CREEK.

On McGinnis Creek, the eastern branch of Montana Creek, are the properties of the Mansfield Gold Mining Company, consisting of both lode and placer claims. These properties are located on the northeastern portion of the wide mineral belt, but all attempts to work either placer or lode deposits have failed, mainly because of their lowness of gold values. During most of the year this property was idle.

There has been no change in the mining conditions or developments on the Montana Basin group of claims at the head of the creek. Small amounts of assessment work were done and some additional surveys made. The inaccessibility and distance from salt water appear to be the chief cause for their nondevelopment.

WINDFALL CREEK.

Just above the divide from Montana Creek, at the head of Windfall Creek, is the Smith & Heid group of claims, located upon low-grade belts of mineralized schist and greenstone, traversed by quartz veinlets in which the gold values are irregularly distributed. There was no renewal of interest in this property during the year.

The first of May the Detroit-Alaska Mining Company began operations on its placer claims on the lower portion of the creek, half a mile above Windfall Lake. Work was continued at intervals until September 15, but owing to lack of water the actual number of days of gravel washing was only 28. A total of 1,000 cubic yards was sluiced. The gravels are of moderate grade and, with a sufficient water supply, should yield profitable returns.

PETERSON CREEK.

On the Peterson group of claims work has been continuous on the gold-quartz veins by the owner and a few helpers. A small testing mill has been erected, and it is reported that from this mill sufficient gold bullion is recovered to defray mining expenses.

EAGLE RIVER.

At the Eagle River mine there has been a steady output during the year, and the 20-stamp mill has been in operation most of the time. The ore body, which is a wide quartz vein containing shoots of rich ore, is displaced by faulting, which is apparently confined to a depth of a few hundred feet from the surface. These displacements have shattered the country rock across considerable width and have been the cause of much trouble in the exploitation of the vein and in the extraction of the ore from it. Late reports, however, state that developments have extended into the solid formation below the faulted area, and that the vein is apparently in place. The total amount of drifting, crosscutting, and shaft sinking amounts to about 6,000 feet.

YANKEE BASIN.

The principal work done in the Yankee Basin area was the driving of a crosscut tunnel to undercut the Dividend and Cascade lodes. This tunnel begins at a point just above the miner's cabin and was 400 feet in length in October of last year. It was estimated to undercut the Dividend lode at a distance of 530 feet and the Cascade at 1,200 feet from the mouth of the tunnel.

Except the small annual developments necessary no important progress was made on any of the other mines or prospects in this belt, extending as far as Berners Bay.

BERNERS BAY.

The limits of the Berners Bay region include the drainage areas of both Johnson and Sherman creeks. Extensive mineral bodies, consisting of huge stockwork deposits, well-defined fissure veins, and lodes, are exposed up these creeks. From these ore bodies the total gold production has been nearly a million dollars in value, the larger portion of which was obtained from the Sherman Creek mine previous to 1900.

Since 1901 the only producing property has been the Jualin mine, located on Johnson Creek, 4 miles from its mouth and 730 feet above tide water. Three separate ore bodies, inclosed in the diorite country rock and having a general northwesterly trend and a dip of 60° NE., are exposed in the mine workings. Of these the foot-wall vein carries the highest values, and upon it mining and developments have been concentrated this last year. This west vein, as it is called, is a strong quartz-filled fissure, about 400 feet in length and averaging 5 feet in width. Just below the adit level a fault was encountered with steep pitch toward the northwest; the displacement, however, was not great and the vein was readily recovered. This year a 50-foot inclined shaft was sunk from the 170-foot level below the adit tunnel.

At this depth, 220 feet below the adit tunnel, drifts were extended to the northwest and southeast along the vein and the ore thus developed was mined.

In 1906 operations were begun the first of May and discontinued in October, and during this period the 10-stamp mill on the property was operated without interruption.

At the other mines within the Berners Bay region no additional developments have been made, principally because of litigation difficulties. The nature of the ore deposits and mine developments at these points was discussed in last year's report.[a]

MINES SOUTH OF JUNEAU.

Mining progress during the last year has been very slight along the mainland belt to the south of Juneau. None of the mines or prospects have been extensively worked, and their production has been nil.

At Taku Harbor and Limestone Inlet gold-bearing veins of exceptional promise are said to have been opened up during the year, but little work was done on them. At Port Snettisham the only work reported was on the Crystal mine. Here the quartz ore was being mined in a small way and milled in the 5-stamp mill on the property, yielding profitable returns. No noteworthy improvements were made on any of the other prospects about this inlet.

To the south the Holkham Bay group of claims, located on the south side of Endicott Arm, is reported to have been sold, and a small crew of men are to be employed during the winter to drive a 400-foot tunnel, which will develop the vein in depth. The ore body is a mineralized quartz lode, in a schist country rock, within 2 miles of the main Coast Range intrusive belt. The ore minerals are galena, arsenical pyrite, pyrite, and small particles of chalcopyrite, all of which occur both in the quartz veinlets and inclosed in fragments of country rock. Sixty per cent of the gold content is said to be free milling, and the concentrates contained in the ore are estimated at 2 per cent. At 1,800 feet elevation a tunnel undercuts the lode 175 feet from its mouth, and from this point nearly 200 feet of drifting has been extended. Other improvements consist mainly of surface cuts exposing the lode at various points along its strike.

At the Sumdum mine, in Holkham Bay, no attempt was made to renew operations, which were discontinued in 1904.

At most of the properties at the head of Windham Bay, which were energetically developed during 1902–3, operations were discontinued soon after that time. The only company which carried on active work in 1906 was the Helvetia Gold Mining Company. Long cross-cut tunnels have been driven into the mineralized belts of schist, and

[a] Wright, F. E. and C. W., Lode mining in southeastern Alaska: Bull. U. S. Geol. Survey No. 284, 1906, pp. 31–34.

quartz stringers were followed by drifts. Tests have been made on the ore obtained in the 10-stamp mill on the Red Wing group, just below this company's property, but apparently the results were not encouraging.

Prospecting on the divide between Windham Bay and Endicott Arm has revealed several quartz veins, carrying moderate values, but their inaccessibility and distance from tide water render them of little economic value at present.

ADMIRALTY ISLAND.

The mining interests on Admiralty Island have changed but little, and on the two properties, the Portage group at Funter Bay and the Mammoth group at Young Bay, there has been a notable lack of development.

The deposit on the Portage group is a mineralized band of chlorite-mica schist, cut by quartz-calcite veinlets and containing small masses and particles of copper and iron sulphides scattered across a width of about 40 feet. This band has been exposed by an open cut, and the ore is apparently of low grade. Just below the open cut a tunnel was started to undercut the lode, 40 feet in depth. When visited, this tunnel was 30 feet in length and had not reached the ore.

Two miles southeast of the Portage group investigations have been in progress by the Mansfield Gold Mining Company on copper deposits, consisting of several quartz ledges, 3 to 6 feet wide, 100 feet or more apart, and striking northwest, parallel with the trend of the country rock. These deposits carry considerable chalcopyrite and pyrrhotite, also some galena and sphalerite. The main vein outcrops at 1,380 feet elevation on the north slope of Funter Mountain, and at this point has been exposed by a 20-foot tunnel and surface stripping. At 550 feet above tide water a crosscut tunnel has been started to investigate these veins in depth, and work in this tunnel will be furthered during the winter months.

On the Mammoth group, to the southeast of the Portage group and on the same mineral zone, the annual assessment work alone was done.

SITKA MINING DISTRICT.

GEOLOGY.

The geology of the Sitka district, which includes Baranof and Chichagof islands, is comparatively simple. The bedded rocks of the islands are in the main broadly folded Devonian limestone and chert beds with interstratified basaltic flows, and overlying these along the outer coast are slate-greenstone strata, which in turn are overlain by a wide belt made up of pre-Cretaceous graywackes and conglomerates. The most recent rock formations are represented by the lava beds

about Mount Edgecumbe. The core of both of the islands is made up of granitic intrusives, forming broad belts that strike across the island in a northwesterly direction and invading all the bedded rocks except the recent lavas. Near the contact of these granite masses are located the mineral deposits.

BARANOF ISLAND.

Many gold- and silver-bearing quartz veins and lodes, usually of low grade, have been discovered in the area adjacent to Silver Bay. Of importance are the Cache, Lucky Chance, Liberty, and Silver Bay prospects, at which much development work was done in former years. For a number of years, however, no attempt has been made to work these properties and only meager developments have been accomplished.

At Rodman Bay, on the north side of the island, mining operations were closed in 1904, and most of the machinery and mine equipment has been sold and removed from the property. A vast amount of capital was invested in these prospects, and not until a railroad and 120-stamp mill had been built did the investors realize the actual value of their mine.

Other prospects were observed in Port Conclusion and Port Lucy, but these, too, have been abandoned.

CHICHAGOF ISLAND.

The only area on Chichagof Island within which auriferous veins of importance have been discovered lies to the east of Cape Edward, an island point projecting into the Pacific Ocean. These deposits were first noted early in 1905 by Indian fishermen, and within the last two years valuable veins have been developed at this locality. The prospects are on the north and south slopes of a mountainous divide between Klag Bay and Hirst Cove. The country rock is made up of an outlying belt of slates, graywackes, and conglomerates constituting the lowlands along the coast and overlying the slate and greenstone tuff beds which compose the flanks of the bordering mountain range. Farther inland and to the east of this series belts of limestone interstratified with metamorphic schists skirt the contact of the granodiorite intrusive which forms the core of the island.

The auriferous veins so far discovered lie near the line of contact between the outlying slate-graywacke beds and the slate-greenstone strata, at a distance of 3 miles from the granodiorite belt to the northeast. These strata strike northwest and dip steeply to the southwest. The veins have a general trend parallel with the rock beds, though some of them crosscut decidedly and in a northerly direction. The occurrence of the ore in shoots is apparent from the localization of very rich ore at certain points and the barrenness of the veins at

other points. The gold is present both native and combined with the sulphides, the latter composing but a small percentage of the ore.

The Young group of claims, generally known as the De Groff mine, extends from tide water on the north side of Klag Bay for over half a mile up a gulch. The principal workings are at 220 feet elevation, where a crosscut 30 feet long undercuts the vein 45 feet in depth, and from the end of this crosscut over 100 feet of drifting has been extended. The vein has also been explored by surface trenches and is found to vary from 2 to 7 feet in width. The ore mined has been principally from the surface outcrops and masses of quartz float near the vein. This has been sorted, sacked, and shipped in several-ton lots to the smelter at Tacoma. The ore, however, is a free-milling quartz rock, and it is planned to erect a 5-stamp mill on the property early in the spring of 1907, and thus save the present shipping and smelting expense.

Just above the Young group to the northwest are the Golden Horn and Golden Gate claims, located upon quartz veins similar to the one already described. The ore body on the Golden Horn claim has been prospected by a tunnel about 40 feet in length, and a vein 3 to 6 feet wide is exposed. On the Golden Gate claim the developments consist of surface cuts exposing a strong fissure vein many hundred feet in length. Though the values are found to be low, shoots of rich ore are likely to occur.

Over the divide and down the north slope of the mountain is the Bear group of claims. The workings are in a gulch half a mile from Hirst Cove and at 440 feet elevation. The quartz vein at this point is but a foot in width, though the country rock itself for a few feet on each side of the vein is sufficiently mineralized to make ore. In strike the vein coincides with the structure of the slate-greenstone schist inclosing rock, which trends N. 50° W. A small shipment of the ore was made to the Tacoma smelter and the returns were reported as favorable.

Along this mineral belt, bordering the outer shore of Chichagof Island, prospecting should be encouraged. The inaccessibility of the valleys and the dense undergrowth present a somewhat formidable outlook to the prospector; a careful search, however, within this area is undoubtedly warranted.

KETCHIKAN MINING DISTRICT.

Gold plays but a very minor rôle in the mining interests of the Ketchikan district, and its production has been largely from the copper ores, which carry from $0.50 to $2 in gold per ton of ore. In this section there are apparently no defined lines or zones along which gold has been extensively distributed. It is found scattered here and there at numerous localities, but at only a few of these have developments been extensive.

PRINCE OF WALES ISLAND.

Near Hollis, on the north side of Twelvemile Arm, are the Crackerjack, Puyallup, Flora and Nellie, Dew Drop, and Julia claims. The most work done in this section was on the Julia claim, situated on Harris Creek, 2½ miles southwest of Hollis and from 800 to 1,200 feet from tide water. At this point a shaft 100 feet deep has been sunk on an incline of 25°. At the 50-foot level a drift has been run 35 feet long, and another started at the 100-foot level. The ore body is a quartz vein, striking north-northwest and dipping 25° SW., in a black-slate country rock. At the surface it has a width of 1 foot of solid quartz. This, however, becomes a stringer lead, consisting of numerous quartz veinlets across a width of 4½ feet, at a depth of 100 feet. The ore contains auriferous pyrite, with some galena and sphalerite. An arrastre was installed and mining on a small scale is to be advanced during the winter.

Investigations at the Crackerjack mine were made by the Brown-Alaska Company early in 1906, but no development work has since been done. The Puyallup mine was leased and prospected by two miners, who discontinued work in February, 1906. The other properties in this section were idle.

At the Treasure group, on Granite Mountain, which promised well to become a producer, only small improvements were made within the year, and on the near-by claims the assessment work alone was done.

At Dolomi a small crew of six men was employed and developments were furthered on the Valparaiso vein. The shaft has been extended to 180 feet in depth, and at the lower level the pay streak is reported to have widened from 16 inches to nearly 30 inches. On the Amazon claim limited explorations were also made underground. On the Paul and Lakeside claims inclined shafts 60 feet deep have been sunk and drifts started on the veins. The properties of the Golden Fleece Mining Company were sold by the action of the court early in the year and no attempt was made to operate them.

The prospects at Dakoo Harbor, on Dall Island, southwest of Prince of Wales Island, have been developed in a small way during the year, though no important improvements in the ore bodies are to be noted. The deposits at this point are quartz veins and lodes of low-grade ore.

GRAVINA ISLAND.

At the Gold Stream mine, on the east side of Gravina Island, operations were renewed July 15 and a dozen or more men were employed until the 1st of October. An exploratory drift was extended in a northwesterly direction from the shaft, and a body of good ore was

exposed. On the surface considerable investigations and improvements were also made. Two smelter shipments of ore were made during the year, but this ore is by no means a smelting ore. It contains a high percentage of free gold and but a small proportion of concentrates, and with careful amalgamation and separation it may be reduced at small cost.

REVILLAGIGEDO ISLAND.

The Sea Level mine, on Thorne Arm, which was one of the first gold mines of the district and has been idle since 1903, was carefully examined late in 1906, with the view of resuming operations early in 1907. The properties in the near vicinity of Ketchikan have all been closed.

CLEVELAND PENINSULA.

Mining and prospecting on Cleveland Peninsula have been confined to Helm Bay and Smuggler Cove, on the southwest end. Mineralization occurs in a narrow belt of schist and slate, and from this belt seams and pockets of rich free-gold ore have been mined. Though numerous claims are located upon this belt, the only important work done during the year was on the Gold Standard and Old Glory groups. At the former a 2-drill compressor plant was installed, besides exploratory work underground. The 5-stamp mill on the property was reported in October to have been in operation for sixty days, crushing 15 tons of ore per day. The richest ore is sorted out and shipped to the smelter. At the Old Glory group small developments were advanced and the ore obtained was treated in the 2-stamp testing mill on the property.

WRANGELL MINING DISTRICT.

Last year brought little progress in the mining enterprises of the Wrangell district. Late in the summer interest was revived on Woewodski Island by the Olympic Mining Company, and a renewed attempt was to be made to mine and mill the ore from the several quartz lodes and veins on this company's properties.

The mineral deposits are zones of brecciation in the greenstone country rock, from 5 to 15 feet in width, into which quartz has been generously introduced, carrying with it sulphide ores and small amounts of gold. But a small percentage of the ore is free milling, and as a whole the deposits are rather low in grade.

Though there are many other prospects in the district there was no gold production and but little mining was done within the year.

SKAGWAY MINING DISTRICT.

GENERAL STATEMENT.

There are no gold-quartz mines in the Skagway district. The only gold produced has been from the placer mines on Porcupine and Nugget creeks in the Chilkat drainage basin and from the beach diggings at Lituya Bay. These placer mines were mostly idle in 1906, and the production for the year was nil.

At Porcupine Creek nothing has been attempted since the washout in July, 1905. At Nugget Creek small improvements were made on some bench claims just above Salmon River, but no work was done on the deposits of this river.

LITUYA BAY.

Lituya Bay forms a deep indentation in the coast line 50 miles to the northwest of Cross Sound. Although it is an excellent harbor, a bar composed of large bowlders and gravel wash almost locks the entrance, and through the boat channel, which is but a hundred feet in width, the tide rushes at great velocity, so that it is dangerous to enter except at slack water during calm weather.

The lowlands flanking the abrupt mountain slopes at the head of the bay are composed of Pliocene conglomerate and shale beds carrying narrow seams of coal, the latter of no commercial importance. These strata overlie a belt of slates and greenstones, which in turn overlie the metamorphic schists exposed along the precipitous shore at the head of the bay. The mountain range in the background is composed essentially of an intrusive granodiorite. Indications of mineralization were observed in these schists bordering the granite belt, and from them the placer gold occurring in the beach sands along the coast is supposed to have originated.

The auriferous beach sands are distributed along the Pacific shore to the northwest of the bay for a distance of about 10 miles, and similar occurrences are reported at Yakutat. These auriferous deposits consist of black and ruby sands, occurring in layers from a few inches to a few feet thick and extending in places for 100 yards back from tide water. The black or magnetite sands are by far the richest, and a pan test gave numerous fine colors ranging from a fraction of a cent to several cents in value.

At a point 4 miles northwest of Lituya Bay a river which flows nearly parallel with the shore for about 3 miles enters the ocean, and here the fine wash which is derived from the mountain streams and carried in suspension is deposited by the counter action of the surf against the stream current. During periods of high tide and storm these auriferous sands are concentrated by the waves in layers high up on the beach. Since 1890 these deposits have been worked a

intervals, and are reported to have produced in 1891 $15,000.[a] In later years even higher returns are said to have been obtained, but no authentic statements could be procured.

In 1901 the Lituya Bay Gold Mining Company built a large warehouse and flumes and installed machinery to conduct large-scale operations, but the limited extent of the pay streaks and lack of near-by water for power and hydraulicking purposes prevented it from furthering the work to a successful outcome. Small parties of miners, however, at different periods have worked these deposits with shovel, sluice box, and rockers to good advantage, and report that the auriferous beds yielded from $5 to $10 a day per man. The presence of gold in these sands appears to warrant a thorough prospecting of the mineral-bearing schists which traverse the head of Lituya Bay and parallel the coast line.

COPPER.

PRODUCTION.

The remarkable increase in the production of copper from the mines on Prince of Wales Island has brought Alaska well to the front as a copper-producing territory. Practically the first shipments were made in the latter part of 1905, and since that time there has been a steadily increasing production. For the most part the ores of southeastern Alaska carry but a small percentage of copper and less than a dollar in gold, and therefore require exceptional mining and transportation conditions to insure profitable extraction.

The following table shows the amount and value of the copper, gold, and silver produced from copper ores in Alaska in 1905:

Production of copper ore in Alaska, 1905.

	Total.	Copper.		Gold.		Silver.	
		Amount.	Value.	Amount.	Value.	Amount.	Value.
	Tons.	*Pounds.*		*Ounces.*		*Ounces.*	
Total	52,199	4,805,238.0	$748,616.00	3,441.84	$71,170.36	26,500.00	$16,021.00
Average......per ton	....	92.6	14.44	.066	1.36	.497	.298

The production for the Prince William Sound area, as well as southeastern Alaska, is included in the above table, thus increasing the total by a little less than 3,000,000 pounds of copper. The ores from the Prince William Sound area are of comparatively high grade, and the averages per ton given in the table are higher than the yield from the ores in southeastern Alaska.

For 1906 the production of copper from southeastern Alaska alone is valued at nearly $1,000,000.

[a] Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 85.

KETCHIKAN MINING DISTRICT.

All the copper-producing mines of southeastern Alaska are on Prince of Wales Island, in the Ketchikan district. The ore bodies are genetically related to the intrusive rocks and occur either as contact or replacement deposits in the form of lenses or irregular masses. They are found in limestone, quartzite, or a greenstone-schist country rock. The chief copper ore is largely chalcopyrite, accompanied by pyrite, magnetite, and pyrrhotite, besides various gangue minerals. Enrichment zones are lacking, evidently on account of the absence of the zone of weathering which was removed during the glacial epoch; and at only one locality (Copper Mountain) are secondary ores present in quantity. At this place they extend only a few hundred feet below the surface.

KASAAN PENINSULA.

Kasaan Peninsula is a promontory 12 miles long and 3 to 6 miles wide, projecting into Clarence Strait and sheltering Kasaan Bay, a deep embayment. Its high points reach elevations of 500 to 3,000 feet, and the mountain mass is made up principally of eruptive rocks. The sedimentaries exposed are small areas of marbleized limestone and schists varying in composition. These are invaded by wide diorite masses and by dikes of felsite, diabase, andesite, and basalt, in many places forming an intricate complex of intrusives, both previous and subsequent to the deposition of the ore bodies. Faulting was observed locally, but displacements were small and their effect on the ore bodies was slight.

The ore bodies occur as lens-shaped masses within the contact aureole of the invading diorite batholiths. The diorite is not invariably exposed on the surface at the mine, but its presence may be usually found in the near vicinity. The presence of a huge underlying mass of igneous rock is clearly shown by the vast amount of contact metamorphism and contact minerals within the ore bodies. Garnet, epidote, hornblende, calcite masses, and many other secondary minerals are present and form the gangue of the copper deposits. Associated with the chalcopyrite is a large percentage of magnetite, thus making a base ore and necessitating the addition of much siliceous ore on its reduction in the smelter. This latter problem has been a source of difficulty the last few years, but has apparently been overcome by the development of extensive bodies of copper-bearing quartz at Maple Bay, on Portland Canal.

There is every reason to suppose that these copper deposits originated from considerable depth and were laid down from the solutions given off during the solidification of the dioritic batholiths. It seems safe to assume, therefore, that other ore bodies similar to those exposed on the surface may be found within the contact zones in depth.

The progress in mining development of the Mamie and Stevenstown mines, on the east side of the peninsula, may be best expressed in the number of tons of ore reduced in the smelter at Hadley, just below the two mines. This smelter, which began operations December 5, 1905, and was in blast at different periods for about two hundred and sixty days during the year 1906, reduced nearly 90,000 tons of ore, most of which was from the two mines mentioned.

At the Mamie mine notable progress was made and its output of ore was increased. Exploratory developments by drifts and diamond drill were also advanced.

The Stevenstown mine has had a successful year, with a large ore production. The ore body is much like that at the Mamie mine, consisting of a flat-lying lens of chalcopyrite-pyrite and some magnetite associated with hornblende and calcite. These lie in a banded garnet-epidote country rock and are crosscut by porphyrytic and diabasic dikes striking in various directions, most of which were intruded subsequent to the deposition of the ore. To the northeast a narrow belt of crystalline limestone was observed at one point overlying the ore body and apparently is the remnant of a broad limestone belt that has been removed by erosion. The developments consist of wide surface pits undercut by tunnels from which the ore is delivered to the aerial tram and thence to the smelter 1 mile distant.

An exploratory tunnel 300 feet in length, which undercuts a low-grade magnetite ore body exposed on the surface, has been driven on the Blue Jay claim, and at other points on the property small cuts and trenches have been made. It is planned to extend the investigation of these deposits by a diamond drill.

On the west slope of Kasaan Peninsula is the Mount Andrew mine, which for several years previous to 1906 was idle. The first of the year operations were renewed and were energetically advanced, so that at the time of the writer's visit, in October, the first ore shipments were being made to the smelter at Crofton, B. C. The underground workings consist of nearly 500 feet of tunnel drifts and crosscuts, and in the main tunnel two workable ore bodies, from 25 to 75 feet in lateral dimensions, have been opened. On the surface a third ore body, similar in size, but of somewhat lower grade, has been partially developed. A cable tram 3,600 feet long has been installed and large ore bins and a wharf have been built at tide water.

From the White Eagle mine a shipment of 350 tons of ore was made in February, but since that time work has been suspended. Prospecting during the summer between the White Eagle and Mount Andrew properties revealed new bodies of copper-bearing ores, which were located and exploitation was begun.

To the northwest, about 3 miles from the village of Kasaan, is the Mammoth group, purchased by the Haida Copper Company in June.

Previous developments at this mine consisted of a shaft 35 feet deep on the ore body, with two crosscuts 30 to 40 feet in length, and a 110-foot tunnel was started to undercut just below the shaft. Under the new management the tunnel was completed and a surface equipment comprising an aerial tram and wharf was being built preparatory to the shipping of ore early in 1907. The mine is at 480 feet elevation and 1,800 feet from tide water. The mineral deposit is a low-grade magnetite-chalcopyrite body with basic gangue minerals and is less than 100 feet in its greatest dimensions.

Four miles northwest of Kasaan post-office, and half a mile from the beach, locations were made in September upon an ore body of the Kasaan type. Soon after its discovery this property was bonded to a mining company that was planning to carry on its investigation during the winter.

Developments on the ore bodies at the Copper Queen mine, the Poor Man's group, and the Sunny Day group of claims, all situated on the Kasaan Bay side of the peninsula, have been suspended, principally on account of litigation, and the required assessment work alone has been done on them during the year.

The mines at Karta Bay, on the northwest end of the peninsula, have added considerable to the copper production of the island. The ore bodies are large magnetic masses, in which chalcopyrite occurs in concentrated patches and irregularly disseminated throughout the whole. These are included in an altered dioritic rock which intrudes and includes narrow beds of limestone and chlorite schist. The surrounding country is comparatively low in elevation, and shaft mining and exploration is a necessity. These magnetic bodies have been located by magnetic surveys, and the largest bodies of ore are apparently at the points of maximum attraction.

The Rush & Brown property, which is connected by a railroad 3½ miles in length with the wharf at Karta Bay, has been the mining center of the Karta Bay area. A lease of this mine was taken by the Alaska Copper Company, and the ore mined, which has amounted to several thousand tons, is shipped to its smelter at Coppermount. The deposit is a body of magnetite-chalcopyrite ore carrying small gold values and inclosed in a diorite country rock. It is oval in cross section, being 150 feet in length and 50 feet in width, and has been developed 100 feet in depth. A second ore body from 10 to 20 feet in width and of greater longitudinal extent occurs about 150 feet to the northeast, and from it much ore has been mined.

On the Venus group, 2 miles south of the Rush & Brown mine, a large body of pyrrhotite-chalcopyrite ore has been exposed by surface strippings and two short tunnels. The ore is low in grade, and little work was done on the property during the year.

SKOWL ARM.

During 1906 the Kiam mine, on Skowl Arm, and the adjoining Mammoth and Lake View groups to the east were idle. The smelter returns from a large shipment of the ore were not satisfactory, and its high content of sulphur made it an undesirable smelting product. After a careful examination made of these properties this last summer the owners decided to discontinue operations at this point.

The ore bodies which have been developed are heavily mineralized masses of pyrite and pyrrhotite ore containing chalcopyrite and occurring in a schist country rock. These masses coincide in trend and dip with the rock structure. At the Kiam mine the mineralized band is continuous over a length of possibly a thousand feet and has an average width of 20 feet, though in places it is 60 feet wide. In depth, however, the deposit was not undercut by the tunnels cross-cutting the ore-bearing zone, and it appears to be limited to some tens of feet from the surface at the point where it has been developed by the Powell tunnel. The tonnage of available ore is therefore relatively small, and though it could be readily mined its value is reported as insufficient for profitable extraction.

The Mammoth and Lake View groups are clearly in the general line of strike with the Kiam ore bodies, and so far as developed the deposits are of the same character. They appear to be merely smaller and weaker examples of the Kiam type.

NORTH ARM.

At the head of North Arm locations were made in 1905 on copper-bearing veins about a mile from tide water and less than a hundred feet in elevation. Early in 1906 these were transferred to the Cymru Mining Company, which immediately began operations and the 1st of October began shipments.

The veins, four of which have been exposed, lie in the limestone and greenstone-schist country rock and strike N. 35° W., nearly parallel to its structure, dipping 70° SE. They vary in width from 1 to 5 feet and contain chalcopyrite and pyrite scattered through a quartz gangue. Near the surface the ore is changed to the oxides and carbonates of iron and copper. A shaft 105 feet deep has been sunk on the larger of these veins and at the 100-foot level a drift extended. A large percentage of the ore mined was from a surface trench 500 feet long and 4 to 8 feet wide, following the vein. From these workings a surface tram leads to ore bunkers, from which the product is loaded directly into hulks or barges for shipment.

NIBLACK ANCHORAGE.

The Niblack mine, on the south side of Niblack Anchorage, has been operated steadily throughout the year and has yielded a large production of copper ore.

The ore bodies occur as mineralized portions of schist bands in a complex consisting chiefly of greenstone schists with a few belts of quartz-sericite schist and allied rock types. The formation strikes N. 60° W., with a dip of 60°-70° SW., and is cut by several later diabase dikes. Folding and faulting occur at many places and have an important bearing on the extent and shape of the ore bodies. Detailed work on these structural features in the mine has shown that the irregular outline of many of the ore bodies is the result of intersecting fault planes. The ore is essentially low-grade chalcopyrite, with small values in gold and silver. Pyrite occurs in great abundance and renders the ore suitable only for smelter treatment. Small veinlets of nearly pure chalcopyrite are associated with ferruginous quartz and constitute then the jasper ore of the miners.

The development work for the year was as follows: Drifting and crosscutting, 1,670 feet; shaft sinking, 80 feet; raises and winzes, 425 feet. The inclined shaft is now 225 feet deep and will be extended to a depth of 300 feet. On the 225-foot level a new ore body 90 feet long and 15 feet wide and following a diabase dike has been exposed. It extends to the 150-foot level above, and the ore from it was being mined.

HETTA INLET.

The mines on the west coast of Prince of Wales Island are centered within a small area about Copper Mountain and along the east shore of Hetta Inlet. A geologic sketch map of this area has already been published, with a description of the mines.[a] Briefly, the ore bodies are masses of chalcopyrite or carbonate ores associated with magnetite and pyrrhotite in a gangue of garnet, epidote, and calcite. As a rule these occur along the contact of a granitic stock, intruding beds of limestone and quartzite. The exceptions are the massive sulphide veins occurring in the greenstone schist at the Corbin and Copper City mines.

Investigations on the New York and Indiana claims, the principal holdings of the Alaska Copper Company, have been advanced throughout the year. The developments consist of several exploratory tunnels at different elevations below the surface exposures of the ore bodies, but no noteworthy ore exposures have been made in them.

On the north slope of Copper Mountain are the Jumbo mine workings, belonging to the Alaska Industrial Company, which are also upon contact deposits of chalcopyrite ore. The principal workings

[a] Bull. U. S. Geol. Survey No. 284, 1906, pp. 50-53.

are on Jumbo No. 4 claim, where three tunnels crosscut the contact zone and expose ore bodies at 1,650, 1,770, and 1,876 feet above sea level, and are themselves connected by raises. Similar ore masses have been opened by surface cuts at 2,000 feet elevation. From this mine a short aerial and surface tram connects with an aerial tram 8,228 feet long, over which the ore will be transported to 3,000-ton bins built on a wharf at tide water.

Other ore bodies developed in former years by this company are Jumbo Nos. 1 and 2 claims, and on the Green Monster group to the east, but these were neglected last year and mining was confined to the above-described property.

A mile to the north of the Jumbo claims are the Houghton claims, located along the granodiorite contact on similar chalcopyrite-magnetite deposits. These were transferred within the year to the Cuprite Copper Company, which has undertaken large developments.

Early in the year the Corbin property, 3 miles north of Copper Harbor, on the east shore of Hetta Inlet, was transferred to the Alaska Metals Company, which has begun developments, consisting essentially in the erection of buildings, a compressor plant, and wharf. The ore body is a narrow vein of massive sulphide ore, carrying but a slight percentage of copper and small values in gold and silver. It follows the general northwesterly structure of the greenstone-schist country rock. At a point 45 feet from the mouth of the tunnel to the south the vein narrows to a mere seam, and in the shaft, 22 feet below the surface, it was faulted. From all indications the deposit appears to be a small ore shoot, less than a hundred feet long and 3 feet wide, pitching at an angle of about 60° NW.

At the Copper City mine, 8 miles south of Copper Harbor, operations began in May and continued throughout the year. The ore body is a narrow vein of massive sulphide ore, occurring in the slate-greenstone schist country rock. The vein parallels the vein structure and varies from 1 foot to 5 feet in width. It is crosscut by dikes of diabase, which apparently are later than the deposition of the ore. Several shipments of the ore were made to the smelter at Tacoma during the year. The principal feature in the mine workings was the development of the vein below the 100-foot level. Along this level the ore body wedged away rather suddenly and was found to be displaced for a short distance toward the foot-wall side. At a point in the drift 60 feet northwest of the shaft a winze was being sunk on the vein to the 200-foot level, and in this a good width of ore was reported.

GRAVINA ISLAND.

Copper-bearing deposits are known to occur on both the south and north ends of Gravina Island. The properties at Seal Bay and on Dall Head were prospected to some extent during the summer, and

on the north end of the island west of Vallenar Bay new ore bodies were located. Developments were advanced by the Victor Copper Mining Company on the Bay View and War Eagle claims at Seal Bay. From the former a small smelter shipment was made, the ore being mined from a quartz vein carrying chalcopyrite, exposed along the south shore of the bay.

WRANGELL DISTRICT.

The mineral bodies exposed at the head of Duncan Canal and on Woewodski Island at the entrance both carry small percentages of copper. At the former locality little advance has been made on the groups of claims owned by the Portage Mountain Mining Company. On Woewodski Island the Olympic Mining Company renewed operations late in the summer at the Smith camp, and further investigations will be made on the quartz veins, which were extensively developed in former years.

SILVER, LEAD, AND ZINC.

Deposits of silver, lead, and zinc are not plentiful along the coastal belt, and except small amounts of silver accompanying the gold and copper ores the production has been nil.

The galena veins recently discovered in Cholmondeley Sound, on Prince of Wales Island, however, promise well to become producers in 1907. The Moonshine group of claims, situated at from 2,000 to 2,400 feet elevation on the east slope of Granite Mountain, in Cholmondeley Sound, was located in the spring and soon after was leased to a mining company, which began operations. The ore body, a well-defined vein or mineralized shear zone, obliquely traverses the limestone-schist country rock in a northeasterly direction and occupies a nearly vertical position. It has been exposed at points along the surface over a length of 600 feet and varies from 2 to 4 feet in width. The ore is massive galena associated with pyrite, chalcopyrite, and zinc blende in a gangue of quartz and calcite. Portions of the vein include brecciated masses of country rock, and at these points the distribution of the ore is irregular. The vein was being developed by two tunnels at 2,000 and 2,200 feet elevation and a shaft at 2,400 feet elevation. An aerial tram 5,000 feet long and a wharf must be built before shipments of the ore can be made.

In the Wrangell district explorations on the silver-lead properties located in Glacier and Groundhog basins on the mainland have been meager, and though these properties have been investigated by outside persons no mining company has yet undertaken their development, owing to their distance from tide water.

NONMETALLIFEROUS MINERAL RESOURCES OF SOUTHEASTERN ALASKA.

By Charles W. Wright.

INTRODUCTION.

The recent developments and increasing production from the gypsum and marble quarries of southeastern Alaska have shown that the nonmetallic deposits are an important resource of this region. Structural minerals, such as marble, granite, gypsum, and cement, are widely distributed along this coast, and, besides these, both mineral and thermal springs have been found and coal seams located, though the latter are of no consequence at present.

Little consideration has been given to the nonmetallic products of this Territory, and the increasing use in the United States for such materials demands a more thorough investigation of these resources. Though distant from the market, many large deposits of structural material are well located for quarrying purposes and transportation by water.

In the following pages a brief description of the known workable deposits is given, together with a short discussion of their distribution and of the characteristics and market value of such nonmetalliferous materials.

ORNAMENTAL AND BUILDING STONES.

GENERAL STATEMENT.

The only stones of value in southeastern Alaska, so far known, are the marbles and granites. The market for these stones is in the cities along the Pacific coast, 600 to 1,000 miles distant. They must, therefore, be of more than ordinary quality to bear the expense of freight, as good stone is found in the vicinity of most large cities, and builders, as a rule, prefer to use a known rock which is near at hand and can be readily obtained.

To place the Alaskan product on the market, it will be necessary to establish supply stations with dressing and cutting plants in the larger seaboard cities, where cheaper and more efficient labor may be obtained than in Alaska. To supply these points, the rough granite

and marble blocks could be transported in hulks or barges carrying several thousand tons at a low freight rate and the necessity of careful handling during shipment would be avoided.

To determine the structural value of a building stone, microscopical, chemical, and physical tests should be made. This is more necessary for marbles and cement stone than for granite. Most university laboratories are equipped for such tests and will make them at a reasonable cost.

MARBLE.

DISTRIBUTION.

Beds of marble are known to occur at points along the mainland portion of southeastern Alaska, as well as on many of the islands. They are invariably at or near the contact of an intrusive belt of granodiorite, which has been one of the principal factors in metamorphosing the original limestone beds to their present crystalline or marbleized condition. The age of the limestone beds is Paleozoic, and only in a few places could a more definite determination be made. The largest deposit of marble under development is on the northwest end of Prince of Wales Island, near Shakan. This and other deposits are described on pages 75–77.

NECESSARY QUALITIES.

Commercially marble includes all limestone rocks susceptible of receiving a good polish and suitable for ornamental work. It is no simple problem to judge the value of a marble deposit, and this can not be done from mere tests of small samples, which, nevertheless, may often give significant results. Some of the more important factors governing the value of a body of marble are the quality and soundness of the material as a whole, extent of the deposit, absence of fractures or joint planes, color, lack of objectionable impurities—such as silica, pyrite, and bitumen—facility of extraction, and location of the deposit relative to the market and transportation.

COMPETITIVE DISTRICTS.

Most of the marble used in western cities for monumental and interior decorative purposes is furnished by eastern dealers and must be shipped across the continent. This is mainly the product of the Vermont and Tennessee quarries or is imported from Italy. Stevens County is the only producing locality in the State of Washington; there are none in Oregon, and but two of importance, the Inyo and Columbia quarries, in California. The total value of the marble production for 1905 from these localities was less than

$150,000. This product sold in a rough state at $1 to $2 per cubic foot, and dressed for ornamental and monumental purposes at $2 to $8 per cubic foot. Cut in slabs 1 inch to 2 inches thick and polished on one side the retail price varied from $0.50 to $1.50 per square foot. The eastern and foreign marbles sold for higher prices.

DESCRIPTION OF LOCALITIES.

PRINCE OF WALES ISLAND.

Several deposits of marble have been located on Prince of Wales Island, and, as stated above, the largest of these is at Marble Creek, a few miles north of Shakan, on the north side of the island. Other deposits are at El Capitan, also near Shakan; on Marble Island, adjacent to the northwest coast of Prince of Wales Island, and at Baldwin and Dolomi, on the east coast of the island.

At the Marble Creek locality are the properties of the Alaska Marble Company, located upon a belt of Devonian limestone half a mile or more in width flanking the contact of an intrusive granite mass which forms the low mountain ridge to the east and which is evidently the direct cause of its alteration to marble. Small dikes of diabase, much altered and faulted, though rare, were observed intersecting the marble beds, and apparently antedate the metamorphism of the limestone and the intrusion of the granite. They are, however, not sufficiently numerous to affect the value or expense of quarrying the marble, and in the present opening only one dike is exposed.

The extent of the deposit has been investigated by a number of drill holes and surface openings, and it is exposed at points over a length of 2 miles and a width of half a mile. Three varieties—pure white, blue veined with white background, and light blue, much of which has a mottled appearance—are found, the pure white rock being the most valuable. All of the marble is free from silica or flint beds, and though thin seams of pyrite were observed they do not occur in a quantity detrimental to the stone. Analysis of the rock shows 99.2 per cent calcium carbonate and 0.3 per cent magnesia. Though not equal to the best Italian grades, this marble is better than most American marbles and in the market will compete on at least equal terms with the Vermont, Georgia, and Tennessee products.

The principal workings on this deposit are 100 feet above sea level on the south side of Marble Creek and 3,200 feet from deep water. A gravity railroad extends from the quarry to the end of the wharf, where loading facilities have been erected. Quarrying has extended below the more or less jointed surface rock, and solid blocks 6 by 6 by 4 feet are being mined and shipped. With increasing depth

both soundness and quality of the marble greatly improve, and flawless blocks of large size may be quarried. The dimensions of these blocks, however, are dependent on the handling capacity of the machinery. Small shipments of this product have been made to many of the large cities as far east as Ohio, though the greater portion is sent to Tacoma, where a cutting and polishing plant has been built. Last year the capacity of the mining plant was materially increased with a view to an enlarged production in 1907.

On the opposite side of the low mountain range a similar marble deposit is exposed, and has been partially developed by the El Capitan Marble Company. This property is located on the north side of Klawak Passage, 6 miles from Shakan village. The marble exposed in the quarry close to tide water is comparable with that at Marble Creek above described, except in solidity. Thin fragments of the marble crumble more readily in the hand, and the position of the present workings is less favorable for extensive quarrying. A thousand feet back from tide water surface cuts and strippings have exposed a much firmer and better marble at the foot of a steep bluff. This company began operations in 1904, installed channeling and gadding machines, erected a marble-sawing plant, and made a small shipment. During the last two years no further quarrying has been done and only small developments have been made.

A number of marble claims were located in 1902 about 30 miles to the south of Shakan, on the northwest side of Marble Island, in Davidson Inlet, but practically no work was done on them and they were relocated in 1906. Several varieties of marble of good quality are exposed and the deposits appear worthy of further investigation.

At Baldwin, near the head of North Arm, an inlet on the east side of Prince of Wales Island, beds of marble have been located and developed by the American Coral Company. The deposit at this point consists of marble beds interstratified with chloritic schists striking N. 65° W., with a nearly vertical dip. The marble varies greatly in color and composition, and although some of it is of excellent quality it would probably be difficult to obtain any large quantity of a uniform grade. Most of the product contains a small percentage of silica and some alumina and magnesia. Pyrite in disseminated particles was also observed in some of the marble. The surface exposures were badly fractured in places, but this condition is probably confined to a depth of 10 to 20 feet from the surface. In 1905 a wharf was built, machinery installed, and buildings erected. In 1906, however, practically no work was done.

At the north entrance to Johnson Inlet, about 3 miles east of Dolomi a second group of claims has been located by this company on a similar marble belt. Work at this point has been meager and but little was accomplished during 1906.

HAM ISLAND.

Two deposits of marble have been developed to some extent on Ham sland, an islet in Blake Channel at the southeast end of Wrangell sland. The Woodbridge-Lowery property lies on the west side and he Miller property on the east side. Exploratory work has been dvanced at both localities, large blocks have been quarried, and from hem many tombstones have been chiseled and polished for local use.

ADMIRALTY ISLAND.

A number of marble deposits occur on Admiralty Island—at Marble 3luffs on the west shore, at Square Cove, at Hood Bay, and in Chiak 3ay. Some of the marble at these points is of excellent quality, but nost of it contains silica and pyrite and is of an inferior grade. The leposits at Marble Bluffs are apparently the most extensive and of etter grade than the others.

OTHER LOCALITIES.

Belts of marble exposed in cliffs at tide water have been located on he north side of George Inlet, also in Carroll Inlet to the southeast, oth located on Revillagigedo Island. The extent and value of these narble beds have not been investigated.

On the mainland to the north, at the head of Limestone Inlet, 30 niles southeast of Juneau, extensive areas of a coarsely crystalline narble are located. The marble is colored and not of the best grade.

GRANITE.

DISTRIBUTION.

The granitic intrusive rocks occupy about one-half of the aggregate and area of southeastern Alaska. (See Pl. III, p. 48.) In composition hey vary from granite to granodiorite and to quartz or hornblende liorite. The core of the Coast Range, as well as the central portion f many of the islands, is composed of this intrusive rock. The metanorphism in the granite, its nonuniformity in color, and the presence f joint cracks, so far as observed, make most of the stone undesirable or building purposes. However, granite masses of good quality, uniorm in color, and favorably located for purposes of quarrying, were bserved along the mainland up Portland Canal, in Behm Canal, at Thomas Bay, and Taku Inlet. On Baranof Island exposures of this ock of similar good quality occur at Gut Bay, on the east side, and at he head of Whale Bay and near Silver Bay, on the west side.

CHARACTERISTICS.

All the granite masses in southeastern Alaska are similar in composition, having plagioclase feldspar as an essential constituent. Hornblende is the usual dark mineral, though biotite mica is present in

much of the rock and in a few places exceeds in amount the hornblende. Quartz is commonly present, though usually in smal amounts. The accessory components are apatite, titanite, and magnetite; secondary minerals, due to general metamorphism, are sericite, epidote, zoisite, chlorite, and calcite. Petrographically much o the rock is related more closely to the diorites than to the granites anc is usually referred to as a diorite.

The prevailing color of the granite is a light gray and only in a few places were pink or reddish masses observed. The grains of the component minerals are ordinarily of medium size, not varying greatly ir the different localities. Evidence of the durability of the granite is afforded in many places where long exposure to the influence of weathering has caused little or no disintegration of the surface.

MARKET.

No attempt has yet been made to quarry or even investigate th Alaskan granite. There is practically no market in Alaska for th stone, and along the Pacific coast to the south the demand has bee supplied by the quarries in the States of Washington, Oregon, anc California.

The long haul necessary to the market appears at first unfavorabl to granite quarrying along this portion of the northwest coast, but th present freight rate of less than $2 per ton to Puget Sound is no greater than the cost of the transportation from some of the quarrie in California to the larger cities. The cost for quarrying the stone i the State of Washington is estimated at 35 cents per cubic foot, an the proportion of marketable rock obtained from the amount quarrie is about 60 per cent.

The value of the production of granite from States along the wes coast amounted to nearly a million dollars in 1905. The averag selling price per cubic foot for building and monumental purposes a the quarries in these States is given in the following table:

Average selling price per cubic foot of granite at the quarries in Pacific coast States.

	Rough.	Dressed.	For curbing.
California	$1.10	$5.20	$0.[illegible]
Washington	.60	2.20	.[illegible]
Oregon	.65	4.00	1.[illegible]

The above prices do not include the cost of transportation, whic is from $0.50 to $3 per ton from the quarries to the cities. Thi adds from 5 to 30 cents to the cost per cubic foot.

GYPSUM.

OCCURRENCE.

Within the last two years extensive developments have been made on beds of gypsum at Iyoukeen Cove, on the east side of Chichagof Island, with encouraging results. The extent of this deposit, which occurs in the bottom of a valley, is practically unknown. There are only two exposures of this rock on Gypsum Creek, namely, at the lower and upper mine workings 1 mile from its mouth, and the entire area except a few outcrops of a cherty limestone is deeply buried by a dense undergrowth. The gypsum beds apparently overlie the Carboniferous rocks exposed along the southwestern shore of the cove and forming the southwestern valley divide, though the area of contact was buried under deep gravel deposits along the beach and in the valley. They are temporarily assigned to late Carboniferous or Permian formations. To the north the mountain is made up of a granite mass intruding the older limestone beds.

The geology in the immediate vicinity of the gypsum beds is obscure and neither foot nor hanging wall has been exposed in the mine workings. Bluffs of a cherty limestone striking northwest and dipping to the northeast are exposed near the entrance to the tunnel at the lower workings. The gypsum beds in the tunnel and lower levels have an east-west to N. 70° E. strike, with a northerly dip of 20° to 60°. Channels representing old watercourses and now filled with gravel wash are numerous throughout this deposit. These gravels resemble unconsolidated conglomerate beds and have been mistaken for both hanging and foot wall of the gypsum beds at points in the workings. A careful inspection of the gravels shows that the wash has the same character as that now in the creek bed. Of significance is the presence of granite cobbles corresponding to the intrusive mass at the head of the creek, which invaded the area subsequent to the deposition of the gypsum beds. Dikes of a basaltic rock were present in the beds, and one of these occurring at the south end of a drift on the first level was mistaken for the foot wall of the deposit.

DEVELOPMENTS.

This deposit, the property of the Pacific Coast Gypsum Company, of Tacoma, Wash., was extensively developed during last year. A wharf 2,000 feet in length extending to deep water, with rock bins of 1,000 tons capacity, has been built, and a railroad to the mine workings a mile from the shore completed. Rock bins of 1,500 tons capacity and a shaft house have been erected at the mine. At the lower workings a shaft 190 feet deep has been sunk, and from this two levels consisting of 600 feet of drifting have been extended, exposing

a deposit 150 by 200 feet in lateral dimensions, though no well-defined limits have yet been reached. At the upper workings, 800 feet to the west, investigations were made in 1905 by a 75-foot shaft and drifts almost entirely in gypsum, but no further work has been done.

Shipments from this mine began in May, and several cargoes of rock have been delivered to the plaster mill at Tacoma, where it is prepared for the market.

MARKET.

Gypsum is in much demand along the Pacific coast as wall plaster, fertilizer, and in the manufacture of cement. The Puget Sound market is supplied in large measure from the deposits in Kansas, Colorado, Wyoming, and Utah. The California market is supplied by local deposits and those in Nevada and Utah. Transportation from these points to the seaboard cities costs from $4 to $7 per ton, and the present market prices in these cities of first-grade gypsum products are as follows: Crude, $5 to $7 per ton; land plaster, $6 to $8 per ton; plaster of Paris, $8 to $11 per ton; wall plaster, $9 to $12 per ton.[a]

CEMENT.

The demand for cement all along the Pacific coast is rapidly increasing, but deposits of raw materials for this industry along the Alaskan coast are of little value. The reason for this, in the first place, is the high cost of the fuel necessary for its manufacture. The difficulty in obtaining efficient and cheap labor, as compared with the Puget Sound area and California, must also be considered, and the long haul necessary to the market is unfavorable to such an industry. To ship the cement rock as mined to a cement factory established somewhere near the point of coal supply and the market would be the most feasible mode of procedure; but to do this would bring little or no profit, as vast areas of cement rock are exposed in the proximity of all the larger cities and can supply the cement plants along the coast for many years to come.[b]

COAL.

The most extensive explorations for coal in southeastern Alaska have been at Kootznahoo Inlet and Murder Cove, on Admiralty Island, and at Hamilton Bay, on Kupreanof Island. At these localities the coal-bearing formations are Tertiary in age and made up of

[a] For descriptions of the gypsum deposits of the United States, introduced by a discussion on the geology, technology, and statistics of gypsum, see Adams, G. I., and others, Gypsum deposits of the United States: Bull. U. S. Geol. Survey No. 223, 1904.

[b] For a discussion of the distribution of cement materials and its industry in the United States, see Eckel, E. C., Cement materials and industry of the United States: Bull. U. S. Geol. Survey No. 243, 1905.

conglomerates, sandstones, and shales. The beds are all more or less faulted and appear to occupy basins formed in the more ancient rock beds. The coal is with few exceptions an impure lignite and occurs in narrow seams of no commercial value.

At Murder Cove explorations were made on a seam 5 feet thick, located 2 miles from deep water. This deposit, which contains the best grade of coal in the region, proved to be of very small extent and not worthy of further development. No developments have been made at any of the above localities and most of the prospects have been abandoned.[a]

[a] For a more detailed discussion of the coal deposits on Admiralty Island see Wright, C. W., A reconnaissance of Admiralty Island: Bull. U. S. Geol. Survey No. 287, 1906, pp. 151-154.

RECONNAISSANCE ON THE PACIFIC COAST FROM YAKUTAT TO ALSEK RIVER.

By Eliot Blackwelder.[a]

GEOGRAPHY.

The region explored in the reconnaissance which forms the subject of this paper lies in the northwestern part of the coastal strip of southeastern Alaska. Roughly the area is about 70 miles long parallel to the coast and extends from 5 to 20 miles back from it.

The most prominent feature of this coast is the steep-fronted range of mountains which extends in a nearly unbroken line from Yakutat Bay to Alsek River and beyond. This coastal range is comparatively low, averaging from 3,000 to 4,000 feet in elevation; but back of it rise serrate snowy ranges of greater altitude. North of or within the mountain front the valleys are filled with ice, so that the region is essentially an ice plateau, which is relatively level in the interior but descends about its edges in the form of protruding glacial lobes. Buried ranges of mountains projecting above this interior ice plateau form nunataks. The front range is separated from the ocean by a coastal plain, which varies from 6 to 15 miles in width. This foreland is without notable relief, except for a few low hills close to the base of the mountains and here and there sand dunes near the coast.

From Cross Sound to Copper River, a distance of more than 350 miles, only one valley penetrates back into the interior of the country, namely, that of Alsek River. This powerful stream rises in the interior plateau of the Yukon Territory and after traversing the coastal mountain belt in a series of narrow canyons emerges suddenly upon the foreland and flows into the Pacific through the divided channels of its delta.

GEOLOGY.

GENERAL STATEMENT.

The ages of the indurated rocks of this region have not yet been determined, but on account of their resemblance to formations in adjacent regions it is thought that they belong largely to the Paleozoic

[a] My associate, Mr. A. G. Maddren, deserves commendation here for his excellent service to the expedition, especially in his capacity as topographer.—E. B.

and perhaps in part to the early Mesozoic era. Two distinct series have been differentiated, and the existence of a third is suspected on the evidence of material brought out from behind the range by glaciers. The two oldest of these series are considerably metamorphosed. The youngest is but little altered. All of them have been intensely and complexly folded and have been broken by overthrusts and tension faults to such a degree that the structural features are most intricate.

FORMATIONS.

METAMORPHIC COMPLEX.

The material brought out from the area of the interior ice fields by the Yakutat and Alsek glaciers comprises a large variety of such metamorphic and igneous rocks as hornblende schist, greenstone, gneiss, marble, granite, diorite, and porphyries. No similar rocks were observed in place at any point in the Coast Range by the writer, and, as they are distinctly more altered than the two other series observed, it is believed that they belong to a still older group of formations.[a]

SCHISTOSE SEDIMENTARIES.

The lowest canyon of Alsek River exhibits a fine section of metamorphosed sedimentary rocks lying in vertical isoclinal folds. The section is incomplete at both ends and the relations of the rocks are as yet unknown. The portion of the series there exhibited consists largely of quartzose schists and phyllites—the metamorphic derivatives of alternating graywackes, quartzites, and slates. On account of the rapid alternations in the composition of the original deposits, the initial bedding of the rocks is still fairly distinct, and it happens that the schistosity is in most places parallel to this bedding. Throughout the exposure numerous small quartz veins and stringers traverse the schists. None of these, however, was found to contain valuable minerals.

YAKUTAT SERIES.[b]

The Yakutat series has been described in detail by several geologists[c] who have studied the rocks about Yakutat Bay. Subsequent exploration shows that the greater part of the Coast Range to the east, at least as far as the east side of the Yakutat Glacier, consists of

[a] From observations on the shores of Russell Fiord, Tarr infers that the green schists and gneisses are stratigraphically continuous with schistose graywackes and slates similar to the second series of the present paper (unpublished evidence, 1905).

[b] The use of the word series is not in accordance with the Survey rules of nomenclature, but is a temporary expedient only, to be abandoned as soon as sufficient detailed work is done to permit the subdivision of the rocks to which it is now applied.

[c] Russell, I. C., Nat. Geog. Mag., vol. 3, 1891, pp. 167–170. Emerson, B. K., Harriman Alaska Expedition, vol. 4, 1904, pp. 49–50, 125–146. Tarr, R. S., and Martin, Lawrence, Bull. Geol. Soc. America, vol. 17, 1906, p. 33.

the same rocks. The contact between this series and the older systems has not yet been discovered, but may be looked for near the head of Ustay River. East of that general vicinity the mountains are composed chiefly of the preceding series. The Yakutat rocks are distinguished from those previously described mainly by a general absence of the effects of metamorphism. The predominant rocks are graywackes and black clay rocks which are slates or shales according to locality. Many of the graywackes are conglomeratic, the conglomerates being internal rather than basal. The pebbles consist of black slate, dark graywackes, limestone, granite, schists, etc.

The stratigraphic succession within the Yakutat series was not definitely ascertained, for the structure of the beds is so complex as to defy analysis without detailed mapping. The writer's present interpretation of the structure suggests that the section is roughly as follows:

2. Slates or graywackes of black and gray color, with local beds of coarse and fine conglomerate. Some of the graywacke members are 200 to 500 feet thick.
1. Bowldery slates—black stratified rocks containing pebbles and bowlders of all sizes and various compositions.

Only the lower member of this section requires further mention. This bowlder deposit consists of black shale or slate in which stratification is usually distinct. Pebbles and bowlders are scattered through it without orderly arrangement. In size they vary from fine gravel to bowlders at least 100 feet in diameter; in composition they include varieties so widely different as granite, white limestone, greenstone, graywacke, and quartzite. Although irregular in form, the bowlders are generally roundish or subangular. They have not the well-rounded contours characteristic of waterworn stones. The general character of the deposit suggests that it may be an offshore formation over which floating icebergs strewed their débris at random.

Fossils are rare in the Yakutat series and are of unsatisfactory nature. Those found consist chiefly of jointed stemlike casts,[a] which may represent plants or possibly worm trails. None are of much value for purposes of correlation with the terranes of other regions.

GLACIAL DEPOSITS.

In view of the great development of glaciers, both now and in the last geologic epoch, it is, on first thought, rather surprising that more extensive deposits of drift are not found in the Yakutat region. The moraines along the east side of Yakutat Bay, stretching out to Ocean Cape, have been described by Tarr and Martin.[b] There appears to be another loop of drift concentric with the south end of

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[a] For similar varieties see Ulrich, E. O., Harriman Alaska Expedition, vol. 4, 1904, pp. 125-146.

[b] Tarr, R. S., and Martin, Lawrence, Bull. Am. Geog. Soc., vol. 38, 1906, pp. 155-160.

Russell Fiord and extending eastward along the base of the range nearly as far as Anklin River. This moraine, with its hillocks and lakes, is believed to have been made by a glacier which formerly occupied Russell Fiord. The glaciers in the front range have left only small and relatively fresh moraines. At the foot of the Yakutat Glacier, the largest lobe of ice between Yakutat Bay and Alsek River, a broad, flat terminal moraine hems in a crescent-shaped lake, which in turn borders the present end of the glacier. This moraine has every appearance of being a comparatively recent deposit.

Aside from the deposits of till there is a vast amount of stratified glacial drift mingled with the strictly fluviatile sands and gravels of the coastal plain.

This alluvium of double origin forms much the largest part of the foreland.

RECENT ALLUVIUM.

The streams coming down from the front range, including the Alsek itself, are engaged in building a plain of sand, gravel, and silt out into the Pacific. The formation of salient deltas is prevented by the strong littoral currents, which sweep the finer detritus along the coast and out of it build bars and spits in favorable situations. To some extent the wind has formed low sand dunes along the coast, but the effectiveness of this process is reduced to a minimum by the dampness and the rapid growth of vegetation.

STRUCTURE.

The structure of the most ancient metamorphic series is not definitely known, but is confidently believed to be highly complex.

Both of the younger bed-rock series are intensely and intricately folded. The folds are as a rule isoclinal and in many places overturned toward the west. The strike of the folds is not everywhere parallel to the axis of the range, as it might be expected to be. Near the Yakutat Glacier it trends north-northwest, making an angle of 40° to 50° with the general axis of the mountains. On this account the individual folds come out successively into the plain and disappear; but as the crumpling is repeated over and over again in about the same plane, no older or younger formations are exposed. The details of structure exhibited by the slaty rocks are in many places extremely complex, but the massive layers of graywacke are more regularly flexed. The structural relation between the Yakutat series and the schistose strata on the Alsek was not determined. The marked difference in metamorphism between the two series is thought to imply that they are separated by an unconformity; if not, then the schists of the Alsek may be merely a more altered eastward extension of the Yakutat slates and graywackes.

PHYSIOGRAPHY.

The front range is a maturely dissected ridge, modified and sharpened in its details by recent glaciation. The valleys on the coastal side present distinct evidence of two cycles of valley development. The older cycle is indicated by shoulders on the spurs at an elevation of 1,200 to 1,500 feet; these are interpreted as representing the bottoms of broad valleys. Above the shoulders the average slope is not steep and the ample tributary gulches have occupied the entire field. Beneath the shoulders the more recent canyons belonging to the second cycle are intrenched. Along the front of the range a series of rocky terraces corresponds to and merges into the high shoulders just mentioned. Another and less continuous line of terraces and flat-topped hills of rock stands at an elevation of about 100 feet along the border of the mountain front. Both sets of benches are attributed to erosion by the waves of the Pacific when it stood farther inland than now.

The following summary of the physiographic history of the region conveys the writer's interpretation of the observed facts. It is presented as a suggestion for more detailed and critical work by future students of the region:

1. *Early erosion cycle.*—Mature dissection of a broad west-northwest uplift.[a] Formation of open main valleys with divides 1,000 to 2,000 feet high, and the production of broad marine shelves by waves cutting on the seaward front of the mountains.
2. *Canyon erosion cycle.*—Rejuvenation of drainage by an uplift amounting to about 1,200 feet. As a result the development of V-shaped canyons within the older valleys. In most places the rejuvenation has not yet reached the heads of the older gulches. Formation of high sea cliffs and low cut terraces on the outer spurs of the mountains.
3. *Glacial erosion cycle.*—Maximum extension of glaciers; excavation of cirques in the heads of the gulches. Ice mounted 1,200 to 1,500 feet higher on the slopes of the valleys than now, and was proportionately more extensive. Most of the large glaciers discharged into the ocean, which skirted the mountain front.
4. *Glacial retreat.*—Uplift of about 100 feet, resulting in the partial uncovering of the coastal plain. Yakutat Bay and Russell Fiord glaciers formed moraines upon the flat before retreating. Other glaciers probably receded before the ocean was excluded from their valleys, and consequently formed no moraines. Plain gradually extended by the deposits of shifting streams. The glaciers decreased to nearly their present size and many of them entirely disappeared.

PROSPECTING.

The district described has been explored to some extent by prospectors since the early nineties, but as yet no deposits of proved value have been discovered. The beach placers about Yakutat Bay have been described by previous observers.[b] Deposits of black sand on Black Sand Island contain small amounts of gold and have been

[a] From results of studies by Russell and by Tarr and Martin it seems probable that this is a rising fault block.

[b] Tarr, R. S., Bull. U. S. Geol. Survey No. 284, 1906, p. 64.

worked in a desultory way by several parties, but without material success. Prospectors who have explored the valley of the Alsek report finding "colors" at several points in the canyons. Aside from these somewhat unpromising occurrences there is no evidence of the existence of gold deposits in the district.

It is stated that there are green stains indicative of copper in the canyon of the Alsek just above the main forks; but nothing is known of the value of the deposit. The slates of the Yakutat series along the front range also contain abundant small nodules and stringers of iron sulphides which probably contain a small percentage of copper. A large vein of this mineral is reported to have been found last summer on the shore of Russell Fiord and a claim has been staked for the purpose of developing the property. Specimens of the ore appear to be chalcopyrite, and as the deposit is located at tide water it may become valuable if sufficiently extensive.

A large portion of the coastal plain east of Yakutat was staked out in oil claims some years ago, evidently on the supposition that it is similar geologically to the plain near Controller Bay. There is not, however, the slightest indication of the presence of oil-bearing rocks in the district, and the claims are now abandoned.

POSSIBLE ROUTES TO THE ALSEK VALLEY.

At present there seems to be no easy way of reaching and exploring the valley of Alsek River. Nevertheless, there are several routes which are feasible, although some of them are more or less dependent on the season of the year and the condition of the glaciers.

From Dry Bay.—Alsek River can be ascended in small boats from its mouth only in time of low water. In the months of June, July, and parts of May and August the lower canyon, 20 miles from its mouth, is usually impassable. At these times the river fills this canyon in the Coast Range from the front of the Alsek Glacier, which forms one wall of the canyon, to the precipitous cliffs of rock on the opposite bank. Although difficult, it is possible even under these conditions to drag boats up along the west bank; but the almost incessant falling of rocks from the cliffs renders such an undertaking eminently perilous. It is said that when the river subsides in the autumn a gravel bar is uncovered and boats may be hauled along this without special danger. Once above this canyon, the navigation of the river appears to involve no great difficulties—at least as far as the abandoned settlement of New Hamburg.

Across the glacier from Yakutat.—In 1898 parties of prospectors reached the Alsek by crossing the ice fields from Russell Fiord. They landed from boats in Northeast Arm and carried their outfits up the moraine of the south branch of the Nunatak Glacier. After reaching the bare ice they were able to sled their baggage about 40 miles, over to

the head of American River, a tributary of the Alsek. Some years later another party attempted to cross by this same route, but were unsuccessful on account of the badly crevassed condition of the glacier. Evidently the feasibility of this route depends on the state of the ice at the time the attempt is made.

It may also be possible to use the Yakutat Glacier in the same way and thus to shorten the distance of ice travel by at least one-half. From Yakutat a party can take boats to Dangerous River and ascend it to the east side of the lake at the foot of the glacier. The Indians say that from this point the interior ice field can be reached by traveling along the edge of the glacier. So far as the writer knows, the route has not yet been actually traversed by either natives or white man.

From Chilkat River.—Another route, which has the advantage of being well known, extends from Chilkat River over Dalton's trail as far as the head of the east branch of the Alsek. This stream is said to be navigable for river skiffs, although somewhat turbulent for ordinary canoes. The first explorers [a] of the Alsek descended this branch to the forks and then reached the coast by way of the main river.

By way of Whitehorse and Dezadeash River.—It is possible to go from Whitehorse to Dezadeash River over a wagon road recently built into the Kluane Lake mining field. Having reached the Dezadeash a party can easily descend by boat into the upper canyon of the main Alsek as far as the first glacier which comes into the river. It is said that this glacier forms a series of rapids which is entirely impassable, but that by making a portage of several miles across the end of the glacier it is possible to reach the river again below. From that point navigation can be resumed and continued to the Pacific.

[a] Glave, E. J., Frank Leslie's Illustrated Newspaper (weekly), vols. 70-71, June 28, 1890, to January 10, 1891.

PETROLEUM AT CONTROLLER BAY.

By G. C. Martin.

INTRODUCTION.

LOCATION.

The Controller Bay petroleum field is located on the north shore of the bay, which is a few miles east of the mouth of Copper River, in longitude 144° to 144° 40′ west, latitude 60° 10′ to 60° 15′ north. The localities at which there are known indications of petroleum are confined to a belt about 25 miles long from east to west and from 4 to 8 miles wide from north to south. (See fig. 1.) This belt is adjoined on the north in part by the Bering River coal field. Its southern border

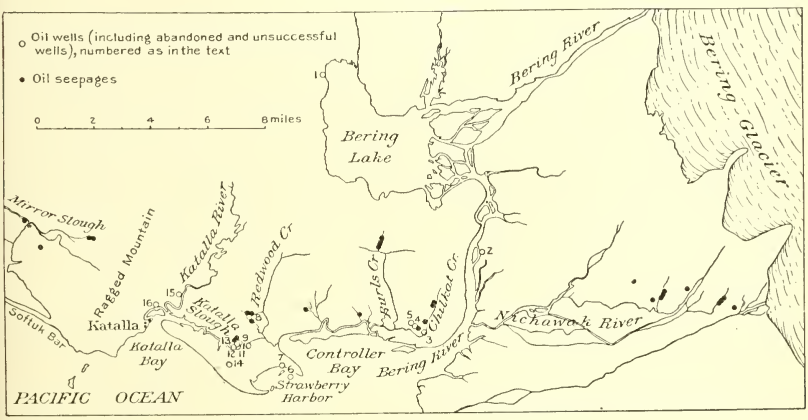

FIG. 1.—Map of Controller Bay oil field, showing position of wells and seepages.

is formed by Controller Bay and the Pacific Ocean and by the alluvial flats on the east shore of Controller Bay. The eastern and western terminations are formed by Bering Glacier and by the Copper River delta, respectively.

OUTLINE OF THE GEOLOGY.

The geology of the region and the occurrence of petroleum have already been described,[a] but more detailed geologic work and further developments have added much to the knowledge which was available

[a] Petroleum fields of Alaska and the Bering River coal fields: Bull. U. S. Geol. Survey No. 225, 1904, pp. 365–382. The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits: Bull. U. S. Geol. Survey No. 250, 1905, 64 pp. Notes on the petroleum fields of Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 128–135.

when these papers were written. A final report on the geology and mineral resources of the region is now in preparation. The present paper contains an abstract of such parts of that report as relate to petroleum.

The general stratigraphic sequence in this region is represented in the following table:

Generalized section of rocks in the Controller Bay region.

Age.	Character of beds.	Thickness.
		Feet.
Quaternary	Fluviatile, glacial, and beach deposits	0-500+
	Marine sands and clays	60
Tertiary	Shales, sandstones, conglomerates, and arkose	12,000+
Paleozoic or Mesozoic (?)	Slate and graywacke with interbedded or intrusive greenstone and other igneous rocks.	

The oldest rocks of the region are the slates and graywackes, with associated igneous rocks, which make up the mass of Ragged Mountain and the low hills west of it and constitute all but the southeastern extremity of Wingham Island. The observed contacts of these rocks with the Tertiary rocks are faults. The amount of metamorphism which these rocks have undergone as compared with the Tertiary rocks, which though in direct contact with them are entirely unmetamorphosed, proves a much greater age for the former and a great unconformity between them and the Tertiary rocks. The lithologic similarity of these older rocks to the Paleozoic or very early Mesozoic rocks at Yakutat, Orca, and Kodiak is suggestive of a corresponding age.

The Tertiary sediments consist of monotonous repetitions of shales and sandstones, with an included mass of coal-bearing arkose, and one or more massive conglomerates. The total thickness, as stated in the foregoing table, is at least 12,000 feet. The structure of the region in which these rocks outcrop is complex, exposures are wanting at many critical points, and neither the lithologic character of the beds nor the fossils which they contain are sufficiently distinctive to make it possible to recognize with certainty the complete stratigraphic succession.

The presence of two easily recognized kinds of rock, the arkose and the conglomerate, gives distinctive character to two parts of the stratigraphic column. The arkose is restricted in areal distribution to the region north of Bering Lake, and the conglomerate to the region south of the lake. Between these regions are areas of no outcrops, and none of the beds of either region can be recognized with certainty in the other. The following sections represent the rocks north and south of the lake:

Section north of Bering Lake.

	Feet.
a. Sandstone	500
b. Shale with thin flaggy sandstones and with occasional calcareous concretions	2,000
c. Arkose with many coal beds and with some shale and sandstone[a]	3,000
d. Shale and sandstone	1,000+

Section south of Bering Lake.

	Feet.
e. Conglomerate and conglomeratic sandstones interbedded with shale and flaggy sandstones	3,000
f. Soft shale with calcareous concretions and with a bed of glauconite near the base	2,000
g. Sandstone	1,000
h. Soft shale	500

The succession in each of these sections may be assumed as reasonably correct, although there is a possibility that the thicknesses are too great because of the repetition of the less characteristic beds by faulting. The correlation of the beds of one section with those of the other rests at present on evidence which is incomplete and unsatisfactory and must be regarded as suggestive rather than proved. It is probable that one of two correlations is true. The shale and sandstone (*d*) may overlie the conglomerates (*e*), with a concealed interval of unknown extent between them; or *a* and *b* may be identical with *g* and *h*. In the former case the conglomerates underlie the coal field; in the latter case the coal underlies all or nearly all of the entire region under discussion. The stratigraphic and structural field evidence proves nothing either way, but suggests, as the most probable relation, that the entire section north of Bering Lake overlies the section south of the lake.

The Quaternary deposits form the surface of practically all the low flats of the entire region. They fill all the large valleys to a considerable depth, which in one place is known to exceed 500 feet.

DEVELOPMENTS.

Active attempts to produce petroleum in commercial quantities in this region have been made for the last five years. The first well was begun in the summer of 1901, but no oil was produced and no great depth was reached, as the tools were soon lost and the well abandoned. The next year the same people drilled another well and obtained some oil. Six wells were being drilled in 1903. The following year witnessed the greatest activity that the region has seen, eight wells being in progress. In 1905 and 1906 operations were restricted to two wells.

The result of these operations has been to obtain one well which yields a moderate amount of oil, another well which is capped, but in

[a] The Kushtaka formation of earlier reports.

which the oil has at times a considerable pressure, and two more wells in which an unknown amount of oil stands near the top of the casing.

Drilling has proved to be very difficult and expensive and the results are not as encouraging as had been hoped. These facts, together with the uncertainty as to the amount of territory which one concern may legally control, and the equally great uncertainty as to the conditions of the market, have led to a suspension of some of the more active operations.

The petroleum obtained in the region, both from the seepages and from the wells, is all a high-grade, light-gravity, refining oil, with paraffin base and high content of naphthas and burning oils. The character of the oil has already been described[a] by the writer and no new information is available.

OCCURRENCE OF PETROLEUM.

SEEPAGES.

GEOGRAPHIC DISTRIBUTION.

It may be seen from inspection of the map (fig. 1) that the seepages all occur within a long, narrow belt extending from the edge of the Copper River delta to Bering Glacier, a distance of about 28 miles from east to west. The belt is very narrow, not exceeding 4 miles at the widest known point, and is parallel to the north shore of Controller Bay, which has the same east-west direction as the larger aspect of the shore of the Pacific Ocean between Copper River and Yakutat Bay. The seepages at Cape Yaktag[b] are also reported to lie on a line having the same direction as this and practically coinciding with it in extended position. Several of the smaller groups of seepages, such as the group on Redwood Creek and at the head of Katalla Slough, and those in the valleys of Burls and Chilkat creeks, and in the Nichawak region, have a distinct linear arrangement, each extending in a direction of about N. 15° E. These lines coincide with the directions of the valleys in which they occur, and the relationship suggested is that either the position of the valley and that of the line of seepages are due to the same cause or that the former is the cause of the latter.

RELATIONS TO KINDS OF ROCKS.

The oil of the seepages reaches the surface through a variety of rocks. (See pp. 93–95.) The seepages west of Katalla are associated with metamorphic rocks, the oil coming to the surface either through the joints and bedding or cleavage planes of the slate and graywacke or through surficial deposits which probably overlie such rocks. The

[a] Bull. U. S. Geol. Survey No. 250, 1905, pp. 57–58.
[b] Locally known as Cape Yakataga.

presence of petroleum in rocks of this character is somewhat unusual and worthy of notice. Similar occurrences of small quantities of oil in metamorphic rocks are known in California and Washington, where the oil is considered to have migrated into the metamorphic rocks subsequent to their alteration. A similar explanation may account for the Alaska occurrence. The writer would suggest as a possible explanation that the metamorphic rocks, which are known to be separated from the Tertiary shales by a fault, are overthrust upon the shales along a fault plane of low hade, and that the oil at the seepages west of Ragged Mountain is coming through the metamorphic rocks from underlying shales.

The seepages at the head of Katalla Slough and on Redwood, Burls, and Chilkat creeks are all in the soft shales, which have previously been called the Katalla formation (*f* of section on p. 91). Those between Redwood and Burls creeks are associated wth conglomerates of presumably higher position (*e* of the section). Such of the seepages of the Nichawak region as have been seen by the writer are in shales which closely resemble those referred to above. The Cape Yaktag seepages are said to be in Miocene sandstones and shales.

RELATION TO THE STRUCTURE.

The position of the seepages with reference to the structure is somewhat vague and uncertain. Those west of Katalla are on steeply folded rocks in which the structural features have not been determined. The group on Redwood Creek and Katalla Slough is apparently in close proximity to a fault. The Burls Creek and Redwood Creek groups are each near the axis of an anticline, the Redwood Creek anticline being probably broken near or west of its axis by a fault. The seepages between Burls and Redwood creeks are on monoclinal conglomerates. The general structure of the Nichawak region has not been determined, but the rocks have steep dips and are probably closely and complexly folded. The Yaktag region, which has not been visited by the writer, is said to have an anticline near and parallel to the coast, north of which the rocks have a monoclinal northward dip. The seepages are said to occur on the north flank of the anticline, parallel to and not far from its axis.

DESCRIPTION OF THE SEEPAGES.

Petroleum seepages and gas springs are very numerous in many parts of the oil belt, and at some of them the flow of oil or of gas is large.

Several large oil seepages were seen by the writer on the banks of Mirror Slough, near the mouth of Martin River. The petroleum comes to the surface from the clay and mud of the valley floor, and a large amount has accumulated in the pools on the swampy surface

and in the soil. The nearest outcrops of hard rock are sandstones or graywackes, probably the same as those on Wingham Island and in Ragged Mountain, and if so of pre-Tertiary age. It seems almost certain that the oil came from these rocks. Seepages were also seen near the head of Mirror Slough at the base of Ragged Mountain. The oil here reaches the surface from the soil, which is underlain either by glacial drift or by talus or landslide débris. The underlying rocks are probably the slate or graywacke referred to above. Another seepage about 1 mile south of this point, in the canyon immediately north of Bald Mountain, was visited by the writer. The oil was here seen oozing in small quantities directly from the joints and bedding planes of the steeply dipping slates and graywackes.

Oil is reported to have been seen in large amounts at the time of the earthquake in September, 1899, on the surface of the water of the small ponds and the creek at the south end of Katalla. The surface material consists of rock débris, largely from Ragged Mountain, underlain by the soft shales previously described as the Katalla formation.

Numerous and copious seepages are to be seen at the head of Katalla Slough. The oil impregnates the soil very completely at many points and has accumulated in large amounts on the surface, but these accumulations are chiefly of oil and are not residues, as at the California brea deposits. No outcrops are near, but the underlying rock is almost certainly the soft shale referred to above, and probably has a steep dip.

On the west slope of the valley of Redwood Creek, about 1½ miles northwest of the mouth of the creek and near a well, oil can be seen coming directly from soft fissile iron-stained shales. The shale has been broken into small angular fragments and recemented by ferruginous material. This condition is common at or near seepages in these shales, but we do not know whether it is a surface condition connected with erosion or whether it indicates crushing of the rocks at a depth below the surface during the process of folding or faulting. Here, as at many other seepages, sulphur springs are associated with the oil. Another seepage was seen near the headwaters of Redwood Creek.

It is reported that oil may be seen at low tide in the beach sands on the north shore of Strawberry Harbor. The rocks in the vicinity are sandstone and shale, probably belonging much higher in the stratigraphic column than the soft shale at the seepages previously described.

There are several seepages along the wagon road which leads from the head of Katalla Slough to the mouth of Bering River. Two of them are located about a mile and a half west of Burls Creek and close to the road. The amount of oil at one of these is large. The

nearest visible rock is steeply dipping conglomerate, which outcrops a few feet away, but the oil can be seen only on the surface of the soil, the direct source not being visible.

The upper part of the valley of Burls Creek contains many seepages at which the oil oozes directly from steeply dipping shales that here contain a large amount of glauconitic grains, making the rock green. Large calcareous concretions are abundant, and many of them take the form of septaria nodules with calcite fillings. Organic remains are frequently seen in the concretions. The soft shale is also rich in organic material, some beds being so dark as to suggest in appearance impure coal. No coal was seen by the writer in the vicinity or anywhere else in these rocks. The rocks seem to be very strongly impregnated with oil in this locality and seepages are numerous, but large surface accumulations are rare. Broken shale recemented by ferruginous material was seen here as on Redwood Creek.

Some seepages with considerable surface accumulation of oil were seen along the edge of the tidal flat close to the wagon road halfway between Burls Creek and the mouth of Bering River. Outcrops were absent in the immediate vicinity, but fragments of shale indicated the presence of such rock.

Several seepages have been reported from Chilkat Creek. The largest one seen by the writer is in the west bank of the creek, 1½ miles above the forks of the wagon road. The oil reaches the surface through soft brecciated shale with a steep westerly dip. The seepage is associated with a black sulphur spring.

Many seepages have been reported in the group of hills centering around Mount Nichawak. Those seen by the writer were small, but the oil issued directly from the rock, which is shale resembling that at the seepages west of Bering River. Others are reported to be located on the banks of a small lake that is said to be covered at times with oil.

Other seepages have been reported from various parts of the Controller Bay region, but they have not been seen by the writer. Reference should be made to those in the vicinity of Cape Yaktag, about 75 miles east of Controller Bay. The amount of oil is said to be very large, the flow being continuous from several of the seepages, one of which has been estimated to yield several barrels of oil per day. The oil is said to come directly from the rocks, which are shales and sandstones of Miocene age, and to come from a line of seepages located along the crest of an anticline parallel to the coast.

Inflammable gas comes to the surface of the water in large amounts in several places. The largest of the "gas springs" seen by the writer are in Mirror Slough and in Katalla River. The former is sufficient to furnish a large continuous flame. The composition of the gas is not known. It issues from the mud on the bottom of the slough.

POSITION AND DESCRIPTION OF WELLS.

The wells in which oil has been obtained in this region are so few that they throw little or no light on the problem of the occurrence of oil. It will be shown in the following pages that a flow of oil has been obtained in one well (No. 10, fig. 1) and less quantities in three others (Nos. 5, 8, and 13). These four wells are close to seepages and are on the outcrop of the shales which have been referred to as the Katalla formation. They are all on lines of seepages having a north-northeast to south-southwest direction, and are all on the steeply dipping northwest flanks of anticlines and possibly on or near lines of faulting. It is unfortunate that no other wells have been drilled in similar positions on the structural lines alluded to above. Such wells might not be successful, but they would test the possible theory that the above-mentioned lines have something to do with the distribution of the oil.

The net result of the drilling has been to show the existence of moderate amounts of oil in at least part of the territory. The wells are neither numerous enough nor deep enough to determine the outline of the pools and the area of productive territory. They have demonstrated the difficulty and expense of drilling and the need of ample resources and careful management. The existence of oil in remunerative quantities has neither been proved nor disproved. The evidence from the existing wells, like that of the seepages, is sufficient to warrant further testing, if it be done intelligently and carefully and by companies strong enough to exploit large areas on a scale which permits of wholesale economies, and also strong enough to risk their capital on what must certainly be regarded as a speculation rather than an investment.

The following list contains an account of each well that has been drilled in the district. The numbers refer to the geographic location of the wells, as shown on the accompanying map (fig. 1, p. 89).

1. West shore of Bering Lake. The surface rocks are sandy shales, presumably underlying the coal-bearing rocks. Dip 12° to 35° NW. Well begun in 1905. Work interrupted by accidents to machinery. Depth several hundred feet.

2. East shore of Bering River. Begun in 1903. Abandoned at depth of 580 feet without reaching bed rock because of difficulty of sinking casing through the mud.

3. Chilkat Creek. Drilled in 1904 to a depth of several hundred feet. No information available.

4. Edge of tide flats 1 mile west of mouth of Bering River. Drilled in 1904 to a depth of several hundred feet.

5. Edge of tide flats a short distance northwest of No. 4. Drilled in 1904 to a depth of several hundred feet. Oil now stands near top of casing. Small but continuous flow of gas. Amount of oil not known.

6. Strawberry Harbor. The derrick was built on piling about 1,000 feet offshore. Casing sunk deep into the mud in 1904 without reaching bed rock.

7. Strawberry Harbor. Drilled several hundred feet in 1904 without obtaining oil.

8. Redwood Creek. Drilled to a depth of several hundred feet in 1904. Oil now stands about 20 feet below the top of the casing. Quantity not known.

9. Near head of Katalla Slough. Drilled to an unknown depth in 1904. No oil, so far as known.

10. Near head of Katalla Slough. Drilled in 1902 to a depth of 366 feet, where a flow of oil was obtained. Drilled to 550 feet in 1903 without further results. In 1904 this well was pumped for fuel at the other wells of the same company. It is now capped, the oil oozing around the casing.

11. Near head of Katalla Slough. Drilled in 1901 and abandoned because of loss of tools.

12. Near head of Katalla Slough. Drilled in 1903 to an unknown depth.

13. Near head of Katalla Slough. Drilled in 1904 to an unknown depth. Now capped, the oil squirting at times in strong jets from the casing.

14. Between head of Katalla Slough and Cave Point. Drilled in 1903 to 1,710 feet and abandoned because limit of outfit was reached.

15. Katalla River. Casing sunk to a depth of 280 feet in 1903 without reaching bed rock.

16. Near Katalla. Two holes have been drilled in 1904 to 1906 on this site, a depth of about 1,500 feet having been reached. Work is still in progress.

PRINCIPLES GOVERNING THE OCCURRENCE OF PETROLEUM.

The four great problems of the geologic occurrence of petroleum are the origin of oil, the movements of oil in the rocks, the stratigraphic and structural distribution of the existing accumulations of oil, and the determination of the location and area of valuable accumulations from the known facts of surface geology.

These problems are stated above in the order of increasing importance from the point of view of immediate utility. The last problem can be solved in either of two ways—by expensive practical testing with the drill or by the solution of the first and second problems, together with a complete and accurate knowledge of the areal geology of the region in which the occurrence of oil is suspected. In the present condition of our knowledge the practical method is the only certain solution of this problem. But all knowledge gained in this way, as well as all facts concerning the geology of the oil-bearing rocks, leads us nearer to the solution of the other problems, and hence hastens the time when we can determine within reasonable limits the presence of oil from our knowledge of the manner in which oil originates and accumulates. The first and second problems are consequently the problems of greatest ultimate importance and should, in a public geologic investigation, be given at least equal weight with the other or immediate commercial problems.

Petroleum occurs in rocks of practically all ages from the oldest Paleozoic to the Recent. All known productive bodies of oil are in rocks of sedimentary origin, such as sandstones or sands, shales or clays, limestones, and conglomerates. Minute quantities of oil have, however, been seen in volcanic or other crystalline rocks.

The origin of petroleum may be explained according to one of two theories. The oil may be of organic origin, having been derived from animal or vegetable matter which was associated with the mineral constituents of the rocks at the time they were deposited, or it may be of inorganic origin, having been formed by the chemical action of water on the formerly unoxidized mineral constituents of the rocks. The prevalent scientific opinion is in favor of the organic theory for the origin of the larger and more widespread accumulations of petroleum.

The movement of petroleum in the rocks is controlled by four factors—the direct action of gravity, capillary attraction, the presence of water, and gas pressure.

The effect of the direct action of gravity is to cause oil to go down as far as the rocks are porous, dry, and not too warm for the oil to exist as such. It will sooner or later be stopped in this downward movement by an impervious stratum (either a bed of close-textured rock or a bed filled with water), and will then move laterally along the upper surface of that stratum to its lowest point, where it will accumulate.

The effect of capillary attraction is to cause the oil to be diffused throughout the rocks in all directions, provided the rock is dry and of the right texture to permit capillary movement. The directions in which it will move will be controlled by the distribution of porous rock and will be modified by the other factors here discussed.

The presence of water causes an upward movement of the oil. The essential conditions for such movement are a porous rock containing both water and oil and a lower limit beyond which the water can not go. The water, because of its greater density, seeks a lower level than the oil and forces it upward until either the demand of all the water for space is satisfied or the oil is checked in its upward movement by an impervious stratum. In the former case the oil rests on the surface of the water in a state of equilibrium; in the latter case it is confined under pressure with a potential upward force.

Gas pressure tends to drive the oil in any unblocked direction. The requisites for oil movement caused by gas are the presence of gas, either in a contiguous body to the oil or being given off from or within the oil, and an impervious bed above the gas through which it can not pass. The gas then tends to accumulate on the upper surface of the oil and to force the oil downward in the direction of least resistance, which may either be vertical or have a lateral component. The oil would already have been in the lowest available space, and so further downward motion implies the displacement of water. The motion continues until there is equilibrium between the expansive pressure of the gas and the hydrostatic pressure of the water. The

oil is then confined between these forces and will escape under pressure at the first opportunity.

The most favorable conditions for the occurrence of petroleum over large and regular areas are the following:

1. A large and widely distributed original source of oil-yielding material.
2. Thick, extensive, and regular porous beds in which the oil can move freely and accumulate.
3. Impervious beds above and below the porous beds.
4. Small angles of dip and fairly regular structure.
5. Absence of deep fracturing or of irregularities of structure.
6. Absence of water in the rocks if the oil-bearing beds are synclinal; or presence of a moderate amount of water if they are anticlinal.

Such conditions are favorable to the occurrence of petroleum in large, regular, and easily outlined pools, to moderately large production and long life of the wells, and to a large degree of certainty in oil prospecting.

These conditions probably nowhere exist in their entirety, at least not over any broad area. Some of the Mississippi Valley and Appalachian oil fields come nearer to satisfying these conditions than any others in North America. It is very evident that few of these conditions are met in the Controller Bay region, and therefore nothing will be gained from further comparison with regions in which simple structure predominates.

Some of the California, Wyoming, and Colorado oil fields are characterized by complex and broken structure, in this respect being not unlike the Controller Bay region. These western fields show that it is possible for large accumulations of oil to exist in rocks with steep dips, irregular folds, and large faults. They show that the structure does not make it impossible for oil to exist in quantity in the region under discussion, but they show also the difficulties of drilling and of locating the pools in such a field, and demonstrate very clearly the need of careful operating and the risks which are necessarily involved.

OUTLOOK FOR PROFITABLE EXPLOITATION.

PROBLEM OF LOCATING POOLS.

If oil is found in quantity it will almost certainly be in circumscribed areas, and the location and boundaries of these areas will be of the utmost importance in the development of the field. The position, size, and shape of these productive areas can not be foretold in advance of all drilling or at the present stage of development. The wells which have been drilled in this region are so few, most of them are so shallow, and so little oil has been obtained that they give almost no light on the occurrence of oil in the rocks. But if at least one area were outlined wholly or in part by the known position of productive

and nonproductive wells it would then be possible to determine the relation of the occurrence of the oil to the geology and from the known facts of the geology to outline other possible productive areas in advance of drilling. For this reason it is of the utmost importance to obtain complete and accurate records of all wells, and to use the information and experience thus gained in locating subsequent wells.

DIFFICULTIES OF DRILLING.

CROOKED HOLES.

Much difficulty has been encountered in keeping the wells vertical, and delay and expense have resulted from the necessity of frequently reaming out the holes in order to straighten them. The crooked holes are the natural result of the steep inclination of the beds, with frequent alternations from hard to soft rocks. Whenever the drill passes from a soft rock to a harder one dipping at a steep angle the drill tends to be deflected and a crooked hole results. This difficulty will always be encountered in this region and will increase the time and cost of drilling. It will, however, become less as the knowledge of the local conditions becomes greater, for the tendency of the drill to deflect can be lessened by drilling slower when the deflecting bed is struck and by special shaping of the tool, and the holes can be straightened more quickly when the drillers have had more experience in the region.

CAVING.

When a well in soft or fractured rock stands uncased too long, the rock caves in, often burying and frequently causing the loss of the tools, and sometimes it is necessary to abandon the well. Much delay has been caused in this way at most of the local wells and it has added greatly to the cost of drilling. It has been impossible on this account to drill several of the wells as deep as they would otherwise have gone. The only remedy is to case the well at the proper time, and when the drillers know better the rocks with which they are dealing they will be able to anticipate the caving and introduce casing at the time when it is needed. Conditions may in this way be expected to improve in the future, and thus the cost will become less and the speed greater and it will be possible to sink wells to greater depths.

WATER.

The rocks of this region are full of water, and consequently large amounts are encountered in all the wells. This is undesirable for two reasons—the pressure of the column of water in the well keeps the oil back in the rocks and prevents it from coming out into the well, and the water reduces the effective weight of the drill and acts as a cushion

between the drill and the rock, in both ways reducing the power of the blow. The only remedy is in casing off the water, which can not be done too often without reducing the size of the hole to undesirable dimensions and finally limiting the depth to which it can be drilled without pulling the casing and going back and reaming out the hole.

REMOTENESS FROM SUPPLIES.

The remoteness of this region from a base of supplies increases the cost of labor and of freight, which will be discussed under a subsequent heading, and also increases the time and expense of drilling, by making it necessary either to carry an exceptionally large equipment of fishing and repairing tools and of general supplies or to be subject to delays in ordering special tools from a long distance. Conditions will improve in this respect with better facilities for communication and transportation, and can also be bettered if machine shops and supply depots are established, as they will be if the presence of productive oil territory is shown.

INEXPERIENCE WITH LOCAL CONDITIONS.

The difficulties caused by the lack of experience of the drillers with the rocks of the local section have already been alluded to under various headings. They may be summarized as including failure to drill slowly or dress the tools so as to avoid deflecting the drill on hard, steeply inclined surfaces; failure to note the crookedness of the hole and remedy it promptly; ignorance of local caving strata and consequent failure to case in time to prevent cavings; and failure to obtain proper and adequate outfit and supplies.

COST OF LABOR AND TRANSPORTATION.

The cost of drilling has been very largely increased over what it would be in more favored and better established oil fields by the high cost of labor and of transportation of men and freight. Not only are the drillers paid higher wages than they would receive at most localities, but the unskilled labor receives excessive pay. It is highly probable that when conditions become more settled and work is done on a larger and more permanent scale wage conditions will become more normal and transportation charges will be reduced.

SHIPMENT AND MARKETS.

If petroleum is produced in commercial quantities at Controller Bay a new set of problems concerning its disposal will arise. All the petroleum of the region, as far as is now known, is a refining oil of high grade, for which there is a good demand on the Pacific coast. The content of extremely volatile constituents, such as gasoline, is so

great that it is questionable whether the oil can be safely shipped in bulk without some refining. There are plenty of good sites for refineries at no great distance from the wells. If a harbor in the vicinity of Katalla or elsewhere on Controller Bay is utilized it will be a very simple matter to transport the oil from the wells to the wharves by short pipe lines on a practically level grade. If no harbor in the immediate vicinity can be used it will be necessary to ship from Orca Bay or elsewhere on Prince William Sound, a distance of about 80 miles westward and across Copper River. The grades to Orca are almost nothing and there will be no difficulties except in crossing Copper River. The distances from Katalla and from Orca to Seattle by the steamer route, "outside way," are about 1,250 and 1,350 statute miles, respectively.

CONCLUSIONS.

The geographic conditions are such as to cause heavy initial expense of prospecting and drilling, but admit of permanent improvements which will make these conditions much better without great engineering difficulties or excessive cost.

The geology is complex and difficult to interpret and does not show definitely the relation of the occurrence of the petroleum to the stratigraphy and structure. The known facts of the local geology are unfavorable to the presence of productive bodies of oil, and indicate that if oil is found in quantity the distribution of the productive areas will be very irregular and difficult to locate.

The surface oil showings (seepages), though widespread and copious, are not conclusive evidence of the occurrence of productive oil pools. They are apparently more promising than any other known facts in regard to the region would indicate. The only safe conclusion to be drawn from them is that they indicate the possibility of productive oil areas in the vicinity.

Operators and investors who may not be familiar with local conditions will do well to be governed by the following suggestions:

1. They should be certain that legal title can be obtained to a sufficient area to make it possible to sink many test wells under widely different conditions, and to expect a large enough probable production to pay for heavy initial expenditures and large permanent improvements.

2. They should have large enough capital to be able (*a*) to purchase in quantity and at low rates; (*b*) to build good roads and other improvements and thus reduce the cost of operating; (*c*) to carry a large stock of tools and supplies in order to avoid costly delays in drilling and to be able to drill deep; (*d*) to procure the best professional advice and good drillers; (*e*) to drill many test wells without hope of immediate profit; (*f*) to market the product in the face of the existing

conditions in the petroleum industry; and (*g*) to afford to lose the investment.

3. The first wells should be located on the strike and at no great distance from producing wells, or down the dip from a good seepage and at such varying distances that the rocks outcropping at the seepage will be encountered at depths ranging from a few hundred feet to the limit (in depth) of drilling.

4. Subsequent wells should be determined in position by the location of existing wells and by the structure. They should be along the strike and close[a] to productive wells, and either not along the strike and at a short distance or on the strike and at a considerable distance from nonproductive wells.

5. Drillers and tool dressers should be obtained from regions where there is difficulty in keeping the holes straight.

6. If oil is obtained it will probably be down the dip rather than up the dip from a seepage, in shallow wells near a seepage, or in deeper wells farther from a seepage.

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[a] The distance should vary with the porosity of the containing horizon.

RECONNAISSANCE IN THE MATANUSKA AND TALKEETNA BASINS, WITH NOTES ON THE PLACERS OF THE ADJACENT REGION.

By Sidney Paige and Adolph Knopf.

INTRODUCTION.

In the following pages are presented the salient features of the geography and geology of a roughly quadrangular area lying adjacent to and northeast of Cook Inlet. The features of direct economic interest will be emphasized here, but the more complete discussion of the geology will be reserved for a fuller report now in preparation. The detailed report will contain a topographic map on a scale of 4 miles to the inch. This same province has been the subject of investigation by Mendenhall,[a] who explored the Matanuska Valley in 1898, and by Eldridge,[b] who explored the Susitna Valley in the same year. In 1905 Martin[c] made a brief study of the Matanuska coal field, which contains the most important of the mineral resources of the province thus far developed. Appended to the present report is a brief account of the more important developments in the placer districts of the adjoining regions.

GEOGRAPHY.

The area studied (see fig. 2) lies partly within the Talkeetna Mountains and partly within the valley of Matanuska River. The Talkeetna Mountains are separated from the main Chugach Range, of which they may be considered a part, by the Matanuska Valley. The Chugach Range trends westward from Mount St. Elias, turns southward at the Matanuska, and forms the eastern mass of Kenai Peninsula. Within the region of the Talkeetna Mountains the peaks rise to a general elevation of 5,000 to 6,000 feet, though altitudes of 8,000 to 9,000 feet are reached in the center of the range.

[a] Mendenhall, W. C., A reconnaissance from Resurrection Bay to Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 265-340.

[b] Eldridge, G. H., A reconnaissance in the Sushitna basin and adjacent territory, Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 1-29.

[c] Martin, G. C., A reconnaissance of the Matanuska coal field, Alaska: Bull. U. S. Geol. Survey No. 289, 1906, 34 pp.

Matanuska River rises on the western margin of the Copper River plateau, flows westward and southwestward between the Talkeetna Mountains and the Chugach Mountains, and enters Knik Arm at its eastern end.

The Talkeetna Mountains are roughly divided into two sections by the drainage of Chickaloon Creek and Talkeetna River. The former heads in a glacier and flows southward for about 30 miles, entering the Matanuska about midway in its course. Talkeetna River rises on the northern side of the Chickaloon Creek divide and flows northwestward and southwestward to Susitna River.

The western portion of the region delimited by this division is characterized by a radial drainage, the great majority of the streams therein flowing away from the center of the area. In the eastern portion the drainage is divided between Matanuska and Copper rivers by a northwestward-trending watershed. The recent drainage has incised many steep-walled canyons, and progress, except along the larger river systems, is exceedingly difficult.

GENERAL GEOLOGY.

STRATIGRAPHY.

The rocks of the area investigated display considerable variety, both of age and of character, ranging from highly crystalline mica schists of unknown age to unconsolidated Pleistocene stream and glacial gravels. The following section shows, provisionally, the stratigraphy of this area:

Provisional statement of stratigraphy of Matanuska and Talkeetna basins.

Age.		Character.	Thickness.
			Feet.
Pleistocene		Stream and glacial gravels	300+
Unconformity.			
Post Eocene		Basaltic lavas, breccias, and tuffs	1,000+
Unconformity.			
Upper Eocene (Kenai)		Coal-bearing shales, sandstones, and conglomerates	3,000±
Unconformity.			
Lower Cretaceous		Limestone	300
Upper Jurassic and upper middle Jurassic.		Shales, sandstones, conglomerate, tuff, and arkose	2,000±
Unconformity.			
Lower middle Jurassic		Graywacke, shales, sandstones, and conglomerate	1,000±
		Greenstones, tuffs, agglomerates, and breccias	1,000+
(?)			
Upper Paleozoic(?).	(Sunrise series).	Graywackes, slates, arkose, and greenstones	(?)
	(Susitna slates).	Slates and graywacke slates	(?)
(?)			
Pre-Silurian(?)		Garnetiferous mica schists, albite-zoisite schists	(?)

The distribution of the above rocks has been indicated in a broad way on the accompanying map (fig. 2). On account of its small scale a condensation of the stratigraphic column was found necessary. An effort has been made, however, to bring out with greater

clearness the facts of possible economic importance. The rocks have been grouped as follows:

1. *Granitic rocks, chiefly quartz diorites.*—These are probably intrusive in rocks as high up in the stratigraphic column as the lower middle Jurassic. They apparently make up the main mass of the Talkeetna Mountains, and occur as isolated bosses on the south side

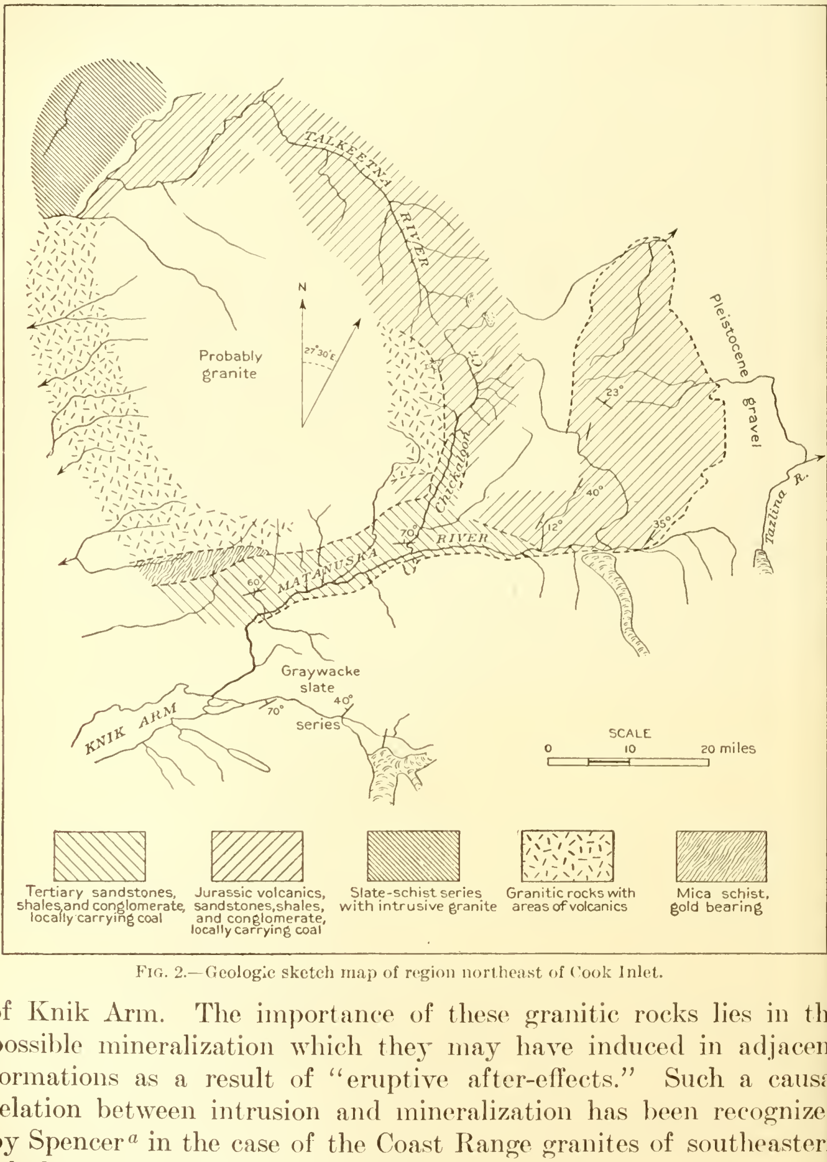

FIG. 2.—Geologic sketch map of region northeast of Cook Inlet.

of Knik Arm. The importance of these granitic rocks lies in the possible mineralization which they may have induced in adjacent formations as a result of "eruptive after-effects." Such a causal relation between intrusion and mineralization has been recognized by Spencer[a] in the case of the Coast Range granites of southeastern Alaska and by Lindgren[b] in California.

[a] Spencer, A. C., Magmatic origin of vein-forming waters in southeastern Alaska: Trans. Am. Inst. Min. Eng., vol. 36, 1906, p. 364.

[b] Lindgren, W., Characteristics of the gold-quartz veins in Victoria: Eng. and Min. Jour., 1905, p. 460.

2. *Mica schists.*—A narrow belt of these rocks borders the granites on their southern side. On account of their strongly foliated and thoroughly metamorphosed character they are regarded as representing the oldest rocks of the region. They possess considerable economic interest from the fact that locally they yield gold-bearing gravels, in places rich enough to be of commercial value.

3. *Slates and graywacke slates.*—These rocks occupy an area near the mouth of Talkeetna River and probably extend up Susitna River. They are known to be more or less gold bearing and have yielded some creek and bar diggings. On account of the lack of fossil evidence the age of these rocks is not known. They show some similarity to the series to be described next.

4. *Graywacke-slate series, including some greenstones.*—These rocks occur on the south side of Knik Arm, and are found striking into the Chugach Mountains on the south side of Matanuska River. They are a continuation of the rocks exposed in the Sunrise district on Turnagain Arm. No fossils have yet been found in them, so that their age is in doubt. They strongly resemble the rocks of Prince William Sound and are regarded by Mendenhall and Moffit as of probable upper Paleozoic age. The slates and graywackes are partially schistose and have been closely folded, uniformly presenting isoclinal dips. They are cut by a great multitude of small quartz stringers, and it is possible that these rocks may yet be found the source of gold placers.

5. *Jurassic.*—All the rocks of Jurassic age have been grouped together on the map. With them is included the lower Cretaceous limestone, whose distribution is limited to the headwater region of Matanuska and Nelchina rivers. These beds contain thin seams of low-grade bituminous coal. This is in marked contrast to certain localities in the Tertiary (Kenai) rocks, where strong seams of high-grade bituminous coal occur, a reversal of the usual state of affairs, in which the older rocks ordinarily carry coal of a higher grade than the younger rocks. In general the Jurassic rocks show only folding of an open character, but minor faulting is of widespread occurrence.

6. *Upper Eocene (Kenai).*—Strata of this age comprise a series of sandstones, shales, and conglomerates, carrying workable seams of bituminous coal, chiefly developed within the lower Matanuska Valley. These beds represent a period of fresh-water sedimentation of upper Eocene age, as shown by the fossil plants contained in them. The rocks are well indurated, and, as first noted by Mendenhall, resemble the Paleozoic coal measures of the Appalachian region. Since they were laid down they have been subjected to sharp folding and now stand in vertical attitude in portions of the area. They are affected by a great number of faults of small throw.

The Kenai rocks of the Matanuska Valley differ markedly from those of the type section of the Kenai as exposed at Kachemak Bay, on Cook Inlet. In this latter locality the sandstones are soft and incoherent, the shales are plastic when wet, and the lignite seams form the resistant members. The beds lie at low angles in undisturbed attitudes. With this lesser degree of alteration and folding may apparently be correlated the fact that the coal of Kachemak Bay is of much lower grade than that of the Matanuska Valley.

The inferior character of the Jurassic coal of the Matanuska region compared to that of some of the Tertiary coal of the same province has already been mentioned. The Tertiary rocks have, as a general rule, been more highly folded than the strata of older age to the north, and it is a fact of some interest that certain *Aucella*-bearing sandstones of upper Jurassic age show a lesser degree of consolidation than the sandstones of the Tertiary.

7. *Pleistocene stream and glacial gravels.*—The larger part of this formation is made up of the glacial and fluvio-glacial gravels which underlie the Copper River plateau to a depth of several hundred feet, as exposed in the gorge of upper Matanuska River. They are probably not of economic importance. These gravels should not be confused with the gravels formed in the present streams.

8. *Dikes.*—In addition to the bedded volcanics of Jurassic and Tertiary ages, dikes and sills of diabase are widely prevalent. They reach their greatest development in the region east of Chickaloon Creek and along Anthracite Ridge between Boulder and Hicks creeks, where they attain a thickness as great as 500 feet. Their texture varies from finely granular to coarse ophitic. They cut all the rocks of the area, and thick sills of diabase are included between strata of Kenai age. It is probable that these sills are the subterranean accompaniments of the great outpouring of Tertiary basalts.

The Tertiary lavas have not been indicated on the map on account of the unnecessary detail which they would introduce. They are widely distributed and cap the older formations, forming many of the peaks and summits of the region.

STRUCTURE.

As Martin has indicated, the general structure of the Tertiary coal-bearing rocks trends northeast and southwest, parallel with the trend of the valley. Open folding parallel with this direction and accompanied by faulting with northeast trend is characteristic. Minor folds with axes in varying directions are present, that at the coal openings on Chickaloon Creek being an example. Here the axis of an anticline and an adjacent syncline trends southeast and northwest.

Along the northern boundary of the field, between Little Susitna River and Eska Creek, the sandstone beds forming the ridge dip

steeply to the south. There is physiographic evidence of faulting at the base of this ridge, as well as of block faulting within the lower hills of the valley. A fault occurs near the base of the mountains on Eska Creek. Another may be observed on Chickaloon Creek, near the northern edge of the valley. The trend of these faults and their occurrence in rough linear arrangement along the northern boundary suggest structural rather than erosive origin of the Matanuska Valley.

East of Hicks Creek the older rocks of Jurassic age do not present the same structural features. The sediments of the upper Jurassic trend northwestward, whereas those of the lower middle Jurassic strike in a northeasterly direction. Block faulting and open folding are present in both of these formations also. More data must be collected before the nature of the relations of the older rocks to those of Tertiary age can be clearly understood.

ECONOMIC GEOLOGY.

COAL.

AREAL DISTRIBUTION.

So far as known, the Tertiary coal-bearing rocks occurring in the Matanuska basin cover an area of about 380 square miles. Coal-bearing rocks of Mesozoic age developed in the upper Matanuska basin cover approximately 500 square miles. The areal extent of these divisions is shown on the map (fig. 2, p. 106) and the character of the beds has been described above. The mapping of the coal-bearing rocks must in no sense be taken to mean that areas so mapped are underlain by workable coal seams. So far as known, the actual area underlain by coal from Tsadaka Creek to Hicks Creek, inclusive, approximates 70 square miles. Localities where coal of commercial importance has been observed will be described.

There are three kinds of coal within the region—anthracite coal, confined to a small area in the Mesozoic rocks; high-grade bituminous coals, occurring in the eastern portion of the Tertiary field; and high-grade lignite, found in the western division of the Tertiary field and in certain localities in the upper Matanuska Valley associated with Mesozoic rocks.

Coal outcrops have been observed on Tsadaka, Eska, Kings and its tributaries, Chickaloon, and Coal creeks; on the small streams heading in the Talkeetna Mountains between Boulder and Hicks creeks; on Hicks and Billy creeks; and on the banks of Matanuska River about 3 miles above the mouth of Chickaloon Creek. They have also been reported from Boulder and Caribou creeks, from a creek on the south side of the Matanuska 9 miles above Coal Creek, and from Little Susitna River.

Last season's work extended the known area of Tertiary coal-bearing rocks approximately 18 miles up Chickaloon Creek, though no outcrops of coal were observed. The discovery of an area of Mesozoic rocks in the upper Matanuska Valley also extends the field in that direction, as indicated on the map, though all the outcrops of coal north of Anthracite Ridge, which lies between Hicks and Boulder creeks, are of a lignitic nature.

The following paragraphs contain a brief description of the several localities where coal has been observed:

ANTHRACITE.

Anthracite occurs along the flanks of the Talkeetna Mountains, between Boulder and Hicks creeks. It has the ordinary physical characteristics of most good coal of this kind, being heavy, firm, hard, and not much fractured. It has a high luster. The seams are not much broken by small partings of shale and bone. Two sections were measured by Martin. One, on the south side of Purinton Creek

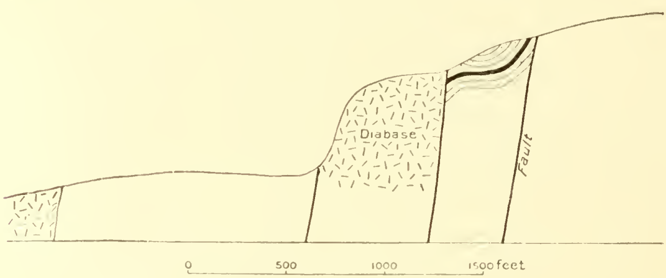

FIG. 3.—Cross section showing relation of anthracite to intrusive diabase near Purinton Creek.

at an elevation of 3,410 feet, showed 38 feet of clean coal with both roof and floor concealed. At this point the rocks strike N. 40° E. (magnetic) and dip 10° NW. into the mountain. The rocks in the vicinity are chiefly graywacke and sandstone and show considerable variation of strike and dip. A mass of diabase occupying the axis of an anticline which is in other places broken by a fault occurs a short distance below the coal.

Martin [a] states that "the anthracite is probably restricted to a zone along the face of and in the mountains which is cut off from the valley plateau by a fault following the base of the mountains."

About a mile northeast of this locality, at an elevation of 3,460 feet, the second section measured by Martin showed four seams of coal aggregating a thickness of 21 feet. The strike is N. 60° E. and the dip 55° SE.

Two sections measured during the last season, farther east on the ridge, showed in one place 7 feet of coal more or less mixed with shale,

[a] Op. cit., p. 18.

and in the other an aggregate thickness of 11 feet 6 inches of coal, though no seam exceeded 2 feet 6 inches in thickness. At the first locality the strike is N. 70° W. (magnetic) and the dip 40° S.; at the second the strike is N. 80° E. (magnetic) and the dip 34° S.

In a small creek west of Purinton Creek is exposed a synclinal of coal, 3 feet thick, cut off by a heavy diabase dike, as shown in fig. 3.

It is believed that the anthracite of this region covers only a small area. The rocks are closely folded, and the seams are cut off by thick diabase dikes. Though it is not certain that the intrusion of diabase dikes is the cause of the anthracitic nature of the coal in this vicinity, its presence at least suggests the possibility of such an influence. At other localities in areas of Tertiary rocks diabase dikes are found in immediate contact with bituminous coals, which in some places have been altered to a dense coke. None of these latter coals can be classed as anthracite. However, in the vicinity of the anthracite, diabase is present in greater mass than elsewhere observed near the coal, and it is reasonable to suppose that the heat derived from its presence was at least a supplemental agency in causing the formation of anthracite.

BITUMINOUS.

The bituminous coal field of the lower Matanuska Valley may be divided into two districts—the eastern and western. Under the first may be included the coals of Kings and Chickaloon creeks and those on both sides of the Matanuska in the vicinity of Chickaloon Creek; under the second, the coals of Tsadaka and Eska creeks.

EASTERN DISTRICT.

Martin[a] states in regard to the coal of the eastern district:

> The coal in this area all possesses about the same physical characteristics, and, as will be seen by the analyses, the variation in chemical composition is not great and supports this grouping. It has the ordinary properties of most bituminous coal. It is soft and fragile, but often without any well-defined planes of fracture. It burns with a short flame and a small amount of smoke and possesses distinct caking properties. The seams generally contain a large amount of impurities, both in the form of thick partings of shale and as thin bands of shale and bone. Many of these can not be separated in mining. The coal is soft and friable, and much of it will not stand severe handling without crushing. Pyrite is present both as balls and as scales, but not abundant. The friable character of the coal is not a great detriment when it is considered that much of it will probably have to be crushed and washed (especially for coke making) and that the coal when used for steam or heating will cake as soon as put in the furnace, so that there will consequently be little or no loss through the grates.

On the south bank of Matanuska River, 3 miles above the mouth of Chickaloon Creek, three coal seams have been found. The upper seam, 7 feet thick, is separated from the middle seam by 43 feet of shale and a 6-inch stringer of coal. The lowest seam, 5 feet 8 inches thick, is separated from the middle seam by 13 feet of shale, which

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[a] Op. cit., p. 19.

includes an 8-inch and a 6-inch seam of coal. The strike at this locality is N. 36° E. (magnetic) and the dip 44° SE.

On Coal Creek, which enters the Matanuska from the south a short distance above Chickaloon Creek, coal occurs at three localities. At the first, at an elevation of 1,010 feet, three benches of coal, 2 feet, 1 foot 5 inches, and 1 foot thick, are separated by sandstone and shale partings. The strike is N. 64° E. and the dip 70° SE. About 500 feet farther upstream coal seams are seen intruded by sills of igneous rock. Here 5 feet 5 inches of coke occurs under an intrusive sill 12 feet thick, mixed with coke and overlying a second intrusive sheet 14 feet thick. Ten feet below this second sheet 6 feet 3 inches of coal, followed by two small seams 6 inches and 9 inches thick, may be seen. The strike and dip are as above. Half a mile above the first coal described a 6-foot seam may be observed striking N. 60° E. and dipping 55° NW. It may be seen from this northwestward dip that a possible syncline exists between this upper coal and the two localities

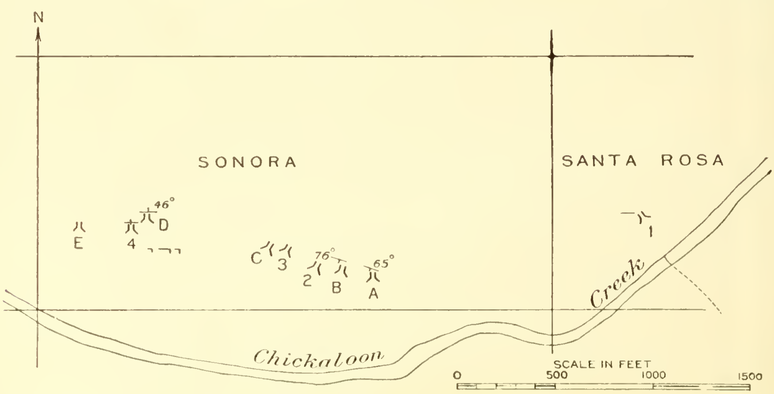


FIG. 4.—Sketch showing location of Chickaloon tunnels.

previously described. As the mouth of Coal Creek is approached a flattening in the dip may be observed, and on crossing the Matanuska and ascending Chickaloon Creek a quarter of a mile an anticline with axis striking N. 50° E. is found crossing the creek. The limbs of this anticline dip at an angle of 30°. Coal was observed in it, but measurements could not be made.

At a point on Chickaloon Creek 1$\frac{3}{4}$ miles above its mouth, but only half a mile in a straight line from the Matanuska, the most important coal openings of this region have been made. Nine tunnels have been driven, crosscutting a number of coal seams cropping in a steep bluff on the north bank of Chickaloon Creek. (See fig. 4.)

Only the thickness of the coal measured in the several tunnels will be given here, the more complete section being reserved for a detailed report. The change of direction of dip which is evident between tunnel D and those farther east (C, 3, 2, B, and A) may possibly be

explained by the presence of an anticlinal axis passing westward from the anticlinal fold at tunnel No. 1, or possibly by irregularities in beds representing the south side of such an anticline. It has been found difficult to correlate the several beds within these tunnels, because of striking irregularities in their thickness. In tunnel A three seams were seen. The first at the face measured 16 feet 7 inches, in which is included a 9-inch layer of bone and coal 1 foot 2 inches from the bottom. The second seam is small, containing but two narrow 8-inch layers separated by 5 inches of bone and shale. The third seam is 3 feet thick and occurs 77 feet from the mouth of the tunnel.

In tunnel B as many as six distinct seams were measured. Several of these, however, contain intervals of shale. Near the face of the tunnel a 2-foot 1-inch seam occurs in which is included 4 inches of bone. On passing outward a thickness of 5 feet 9 inches of sandstone brings the section to a 17-foot 3-inch seam. As in tunnel A, a 1-foot interval of bone is seen near its floor. This seam is undoubtedly to be correlated with the thick seam of tunnel A. Toward the mouth of the tunnel the following coal occurs: A 6-foot seam of bony coal in which is included a foot of sandstone; a 2-foot 4-inch seam of coal; a 7-foot 6-inch seam, at the top of which is 1 foot of bone. Two feet below this seam is 3 feet 7 inches of coal, 7 inches of which is bone.

In tunnel No. 2 a thick bony seam that occurs in B was measured, but shows 12 feet 11 inches. It is in this tunnel very bony and includes 1 foot 6 inches of shale near its middle. A drift has been run from B to No. 2, so that there is no doubt of the correlation. A second seam, separated from this one by 18 feet of shale, measures 4 feet, 7 inches of which is bony.

Tunnel No. 3 reveals the thick seam at the face. Its total width could not be seen, but 7 feet 10 inches may be measured, including a 2-foot interval of shale which probably corresponds to the 1 foot 6 inches of shale in the same seam in tunnel No. 2. The second seam of tunnel No. 2 has in No. 3, 2 feet 5 inches of very bony coal in its center. Its total width is 16 feet 2 inches. About 20 feet from the mouth of tunnel No. 3 a third seam measures 4 feet 1 inch. Small streaks of bone occur in it.

In tunnel C but one small seam was measured. It was 4 feet thick, 2 feet of which was coal with shale.

In tunnel D two seams of crushed coal, each 2 feet 6 inches thick and separated by 49 feet of sandstones and shale, were seen.

In tunnel E 10 feet 11 inches of coal containing several 6-inch streaks of bone and 2 feet of crushed shale mixed with coal was seen.

At the face of tunnel No. 4 a thickness of 5 feet of crushed coal was exposed

Considerable variation in the thickness and in some places unex-pected interruptions of the seams are disclosed in these tunnel Whether faulting or pinching out of the coal be the explanation, fu ther work must show. The rocks in the near vicinity are closely folde and faulting, with the added difficulties of mining which it incur should be expected.

On Kings Creek, 7½ miles above its junction with the Matanusk coal seams are cut by the creek, on both sides of which they were mea ured. A seam of impure coal 6 feet 6 inches thick, overlain by 5 fe 5 inches of dense impure coke, is seen on the east bank. On the we bank coal occupying a stratigraphic position approximately 6 fe lower than this seam measures 10 feet in thickness. In it are sever streaks of bone 4 to 8 inches in width. The strike is N. 42° W. (ma netic) and the dip 42° NE. A short distance upstream from the exp sure on the east side the sandstone beds are considerably disturbe Folding or faulting, or possibly both, has occurred.

On Young Creek, a tributary of Kings Creek from the west, 1 foot inch of coal was seen by Martin, and below it a 6-inch seam was foun Workable seams are reported on this creek. The strike of the beds this locality is N. 15° E. (magnetic) and the dip 20° NW.

WESTERN DISTRICT.

The coal of what has been termed the western district—i. e., th occurring on Tsadaka and Eska creeks—is a bituminous coal of lo grade. Its physical properties are much the same as those of the coa farther east. Most of it is bright and hard, though dull shaly ban are numerous. On Eska Creek, at an elevation of 875 feet, 7 feet inches of coal in which are included four shale streaks and some bo coal was measured. The strike is N. 30° E. (magnetic) and the d 44° NW.

About 300 feet farther upstream 7 feet of coal is exposed, 15 inches it being made up by the shale streaks. This coal dips to the northwes

About 600 feet above the section first cited 2 feet 6 inches of clea coal and 1 foot or more of dirty coal may be seen dipping 32° SE.

On the west bank of the creek, at an elevation of 1,030 feet, a stee bluff made by stream erosion reveals a number of seams of coal. marked fault cuts this bluff. The strata above it, in which the co was measured, strike N. 40° W. (magnetic) and dip 40° SW. Belo the fault the beds strike northeastward and dip to the southeast. A the top of this section are three seams, none of which exceeds 2 fe 3 inches in thickness. They are separated by small intervals of shal About 12 feet lower in the bluff follow coal and shale bands aggreg ting 12 feet in thickness, but containing no solid coal thicker than feet 1 inch. Two 1-inch seams separated by 2 feet of shale occur 1 feet lower.

On Moose Creek about 11 feet of good coal is exposed 100 yards below the upper cabin. The seam strikes N. 80° E. and dips 45° N. A strike fault dipping 80° S. can be seen crossing the bed, with a throw of about 5 feet. An eighth of a mile downstream from this exposure a sharp syncline crosses the creek, with axis striking about S. 70° E. and dipping steeply to the west.

A short distance farther downstream coal beds are exposed striking N. 70° E. and dipping 60° N. This direction does not accord exactly with the synclinal axis. In these beds the thickest seam measured 3 feet 6 inches of clean coal. Higher in the section were found two seams, each 1 foot 7 inches thick, but consisting partly of bone.

On passing up Moose Creek and following the ridge on its southern side sandstones may be observed dipping to the southeast, which is the opposite direction from that of the beds just described. Still farther east conglomerate beds dip to the southwest. There is undoubtedly block faulting within this area, and should the coal beds be followed eastward it would probably be encountered.

It will be noted that at nearly all the localities above described faulting or folding is present. Such a condition will surely place the cost of mining higher than it would be if the beds were less disturbed.

LIGNITIC COALS.

At various points in the region north of Matanuska River thin seams of coal were found in rocks of Jurassic age. None exceed 3 feet in thickness. In the vicinity of Billy and upper Caribou creeks the highly shattered condition of the strata is unfavorable to the presence of workable deposits of coal.

On Billy Creek is exposed an interesting section showing very clearly the complex history through which the coal has gone since its formation. The coal-bearing strata have been folded into a closely appressed anticline. Subsequently they have been cut by basaltic dikes, coking the coal at the contacts. The dikes have been faulted, with a displacement of 5 feet, and the coal has been crushed and sheared, and finally small stringers of quartz, 2 to 3 inches thick, have been formed, accompanied by veinlets of calcite in the coal.

GOLD.

DISTRIBUTION OF GOLD-BEARING ROCKS.

Gold-bearing rocks are found over considerable areas in the region adjacent to Cook Inlet. A graywacke and slate series cut by small quartz stringers occupies the eastern part of Kenai Peninsula, extends across Turnagain Arm, and may be seen in the valley of Knik River still farther north. The search for placer gold in rocks of this type is warranted and discoveries of commercial quantities may be expected where they appear.

North of Matanuska River, on the southern margin of a granit mass, occurs a band of highly crystalline mica schist. It is closel folded and infiltrated with fine quartz stringers, and streams cuttin it yield gold placers. It is noteworthy that the igneous rocks, gra nitic and volcanic, to which this schist gives way on the north an east have so far proved barren of workable placers.

To the northwest, near the mouth of Talkeetna River, a slate-schis series, folded, intruded by granite, and containing abundant quart stringers, represents the gold-bearing rocks. Eldridge [a] reports th occurrence of similar rocks north of the Susitna-Tanana divide. Som gold has been found in the past on streams heading within this for mation. The gold-bearing gravels of the new Yentna district ar reported to have a slate bed rock, indicating the presence of the sam formation.

Though there is yet some question as to the relative ages of thes several series of rocks, there is little doubt that their economic impor tance is due to the mineralization accompanying local infiltration o quartz stringers. In the subsequent wearing away of the rocks th gold content therein has been concentrated in the form of placers.

Though placers have not been found within the areas of older vo canic rocks, some mineralization has occurred. West of Hicks Cree a large cropping of gossan was found. This gossan is due to the ox dation of finely divided pyrite disseminated through a quartz por phyry. A sample selected for assay showed a trace of gold and n silver.

The whole southern flank of Sheep Mountain, at the head of Mata nuska River, is colored a strong red from the oxidation of pyrite in th greenstones. At some points the sulphuric acid formed during th oxidation of the pyrite has bleached the greenstones entirely whit and this bright color, contrasting vividly with the red, produces marked scenic effect. Certain streams emerging from the range are s highly charged with iron salts as to coat their gravels red with oxid The mineralization of the greenstones, which are here roughly schi tose, is extensive but diffuse. An assay showed the presence of a trac of gold, but no silver.

DESCRIPTION OF LOCALITIES.

WILLOW CREEK.

Placer gold is being mined in commercial quantities only at o locality within the area covered during the season—on Grubsta Gulch, a southern tributary of Willow Creek, which enters Susit River about 30 miles above its mouth. Willow Creek proper w staked by M. J. Morris and L. Herndon in 1898, and it is reported th

[a] Eldridge, G. H., A reconnaissance in the Susitna basin and adjacent territory, Alaska: Twenti Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 15-16.

they extracted about $4,000. In 1899 A. Gilbert staked Grubstake Gulch and in 1900 sold his interest to O. G. Herning, who manages the property for the Klondike Boston Mining Company, of Boston, Mass.

The valleys of Willow Creek and of the small tributary gulches show clearly the results of ice action, the side streams occupying hanging valleys, with steep gradients or falls where the smaller streams join the main watercourses. Grubstake Gulch is an example of such conditions. Near its mouth a rim of bed rock crosses the stream and is cut through by the present stream, which falls precipitously about 150 feet in a very short distance and enters Willow Creek at a low gradient. An excellent dump for hydraulicking is thus afforded. The bed rock is a mica schist, penetrated by minute veinlets and augen of quartz. The schistosity at this point is S. 60° W., with a steep dip (40°) to the north. The fact that the direction of the schistosity is across the stream with the dip downstream is especially favorable for the collection of any gold that might be concentrated from the rocks in the process of erosion which the valley has undergone.

In the last three years, during which time hydraulic methods have been in use, 900 feet of the creek has been worked out. Pay averages 200 feet in width, with a depth of 2½ to 3 feet. The gold is coarse and rough and at the mint assays $16.58. Very little black sand is found. The greater part of the gold occurs close to or in crevices of the bed rock, but it is not deemed necessary to clean up by hand, the hydraulic giant being relied on entirely to sweep all gold into the boxes. The wash, which is practically all confined to the gulch bed, there being no well-defined bench, is coarse, ill sorted, and not greatly waterworn. Many large bowlders make it necessary to employ at least two men in breaking up and removing oversize, which adds materially to the cost of extraction. Three Hendy giants are installed on the property, two No. 2 and one No. 1. Only one is used at a time, however. Seven hundred inches of water at a pressure of 180 feet is brought three-fourths of a mile down the gulch. A 24-inch pipe at the intake dam is reduced to 9 inches at the giant, to which is fitted a 3-inch nozzle. The 900 feet of sluice boxes used are built entirely of whip-sawed lumber. The bottom boards are 1½ inches thick and the side boards 1 inch thick; the frames are 3-inch square timbers. The flume is 27 inches wide and 30 inches deep, inside measurements. Block riffles are used. A grade of 5¼ inches to 12½ feet is maintained. The gravel is piped downstream into the boxes. Very little gold is caught below the fourth box, the greater part being retained in the second. Mercury is placed in the third, fourth, and fifth boxes.

The origin of the gold may be with certainty accorded to the quartz stringers abundant in the mica-schists. The coarseness and roughness of the grains suggest a near source of supply. It is very probable that the discovery of placer gold in commercial quantities in

this region will be in the areas where mica schist is the dominan formation or where streams have cut rocks of that type. The fa that placer gold has not been found in paying quantities whe streams have headed in granitic or other crystalline rocks bears o this statement.

Recent prospecting has developed the fact that a well-define bench occurring about 75 feet above the bed of Willow Creek carri gold in commercial quantities. It is planned to install during t coming winter a hydraulic plant for their exploitation near t mouth of Wet Gulch, 2 miles below Grubstake Gulch, on the sou side. The location, with excellent facilities for dump and a catchme area at least as large as that of Grubstake Gulch supplying wat under sufficient pressure, suggests a commercial proposition we worth investigation. The possession of the creek claims as dumpi ground will be necessary. Such bench claims lend themselves pa ticularly to exploitation by hydraulic methods and may be work at far lower cost than gravels situated at the level of present strea drainage.

NELCHINA RIVER.

Two prospectors from Copper Center were met in the headwat country of Nelchina and Tyone rivers. Gold was reported prese in all the stream gravels, but in very small quantities. The go obtained on the Tyone is almost exclusively in the form of sma round plates, worth about a cent a piece. Occasionally small shot nuggets are found, not exceeding 5 or 10 cents in value.

Panning of the hard conglomerate interstratified with Jurass shales and sandstones failed to yield colors. Yet, in view of t unaltered and unmineralized character of the prevailing sandston and shales and the comparative coarseness of the gold, it is neverth less probable that the meager gold content of the present strea channels has been derived by a concentration of the ancient co glomerates.

KNIK RIVER.

It is reported that prospectors discovered gold on Metal Creek, tributary of Knik River, \$7 or \$8 a day to the shovel being claime

YENTNA DISTRICT.

The following data are compiled from various sources: The plac gold diggings of the New Yentna district are located approximate 75 miles northwest of the mouth of Susitna River where it ent Cook Inlet. They occupy in the main the headwaters of Kahiltn River, a northern tributary of the Yentna, 25 miles above the latter confluence with the Susitna. The Yentna heads in the Alaska Rang and enters the Susitna 20 miles above its mouth.

Except the diggings of Lake Creek, a tributary to Yentna River from the north about 10 miles above the Kahiltna, the workable ground may all be classed as shallow, varying in depth from bare bed rock to 5 feet. On Lake Creek the surface gravels only are washed, bed rock never having been reached. It is reported that the pay is from 2 to 5 feet deep and varies in width from 10 to 30 feet.

The gold, with which much black sand occurs, is fine, and at Susitna station (at the junction of Yentna and Susitna rivers) brings $15.75.

About 35 miles above its mouth Kahiltna River forks, its eastern branch being called Peters Creek. Near the head of the latter are Willow and Poorman creeks, both fair producers during the last season. Poorman Creek is tributary to Willow Creek, which in turn enters Cottonwood Creek, a tributary of Peters Creek, between the upper and lower canyons.

The remaining creeks of first importance are all western tributaries of Cache Creek, which enters the western branch of Kahiltna River from the northeast about 20 miles above the mouth of Peters Creek. They are, in order, proceeding upstream, Dollar, Falls and its tributary Treasure, Thunder, and Nugget creeks. They are all located above timber and are characterized by shallow ground and coarse gold. An ounce to the shovel was generally obtained. The bed rock on all these creeks is reported to be slate.

During the open season the steamer *Caswell* and several gasoline launches run from Tyonek, on Cook Inlet, to Lake Creek. A trail to the diggings from Youngstown, on the Yentna, 40 miles above Lake Creek, is also used.

It is probable that $35,000 is very close to the actual production of the district.

SUNRISE DISTRICT.

The following notes on the status of mining in the Sunrise district were gathered at the end of the field season while en route to Seward. The greater part of the mining done last season was confined to Resurrection Creek and its tributaries, Crow Creek, Sixmile Creek, East Fork, Canyon Creek, and Mills Creek. A small amount of work was probably done on a number of other streams, but the quantity of gold produced could not have been great.

Mining has been in progress for a number of years[a] on all the above-named creeks. The richer and more easily accessible portion of the gold content has been removed. Present mining is confined largely to the working of high benches, which, though containing less gold, lend themselves by their position to more economical methods of mining than can be pursued in the creek bottoms. The utilization of

[a] Moffit, F. H., Mineral resources of Kenai Peninsula, Alaska: Bull. U. S. Geol. Survey No. 277, 1906, pp. 33-43.

water under pressure brought by ditches or pipe lines to hydraulic giants is the method most generally employed.

Little mining was done on Resurrection Creek during the season of 1906. A dredge installed in 1905 did not prove a success. The shallowness of the ground and the presence of bowlders of such size as to effectually prevent successful operation appear to have led to this result.

A hydraulic plant on Rainbow Creek, which enters Turnagain Arm on the north opposite Resurrection Creek, was not working during the past season.

Developments on a large scale were made on Crow Creek, a northwest tributary of Glacier Creek, which enters Turnagain Arm on its northern shore 8½ miles east of the town of Sunrise. The Crow Creek Consolidated Mining Company began operations June 6, a large hydraulic plant having been installed under exceptional difficulties at a point a short distance above the junction of Crow and Glacier creeks.

The deposit being mined, aside from its economic value, is of considerable interest in a study of the development of the adjacent region. The following points are to be noted: First, a rock gorge of considerable depth cut in bed rock; second, the gorge, as well as a considerable extent of territory on each side, filled or overlain by a notable thickness of water-laid sands, silts, and gravels; third, recent stream action, superimposed upon these gravels, cutting through them, and forming the present gorge, now far below the older one.

It seems reasonable that the cutting of the first gorge may be referred to preglacial stream action. The glacial striæ and rounded surfaces on the exposed bed rock below the pit at the old level of erosion are excellent evidence of the former presence of the ice. The encroachment of the ice down the main valley of Glacier Creek and the accompanying occupancy of Crow Creek by a glacier would account for a cessation of the cutting of the old gorge. It is assumed that either the mass of the trunk glacier acted as a barrier while the side gulch was already clear of ice, or lateral morainal deposits from the trunk glacier were sufficient to dam the valley of Crow Creek, offering an opportunity for the filling of the old valley of that stream by a process of intermittent flood and low-water deposition. The character of the sediments exposed in the upper pit would strongly suggest such an origin for them. Moreover, the cemented condition of the old gravels lying immediately next the old bed-rock surface is evidence of a quiescent stage in their history such as might occur were they buried in a lake deposit. The erosion of a new channel through this thickness of gravels, sands, and silts, with the consequent formation of the present gorge, was the final step in the history of this creek.

The following is a description of the plant: Water is supplied by a

itch 5,700 feet in length, 6 feet wide at the top and 4 feet at the ottom, and 4 feet deep. To the ditch is added a pipe line 3,000 feet ng, reduced from 24 inches in diameter at the ditch intake to 15 ches at the giant. An abundance of water was obtained until Sepmber 8, when the supply fell below 2,000 miner's inches, a quantity sufficient to work to the best advantage a plant of this size. Operaons may begin as early as May 15. Two No. 7 giants, with 15-ch intakes, were installed. The pressure varied between 280 and 30 feet, depending on the position in the pit.

Up to September 21 200,000 yards had been moved. The goldving apparatus consisted of a string of sluice boxes 200 feet in length ccupying a bed-rock cut at a grade of 8 inches in 12 feet. Ample ump space is afforded by a rather peculiar topographic feature. The ay gravel occupies an old stream channel cut in a steep gorge of bed ock. Cutting through this old bed is the present more recent creek ourse, which has lowered its level many feet below th old channel. s a result, there is excellent opportunity for the disposal of tailings. he sluice boxes are 5 feet 3 inches wide inside the lining boards. welve-inch cube hemlock block riffles are used. Their life is about iree months. It is found that hemlock from this region is tougher d wears longer than the fir of the western United States. Attached the end of the tail sluice is an undercurrent. It is divided into iree tables, each 6 by 30 feet, fitted with 6 by 2 by 2 inch block ffles nailed to a cross strip. The first 4 feet of each table, however, fitted with rock riffles, which, though they offer a slight disadvange in the difficulty of setting up and removal, can be commended ecause of their durability and efficiency. The presence of numerous rge bowlders required the installation of a tram from the pit to the ilings pile. Bowlders less than a foot in diameter which the ydraulic giant is unable to move are trammed out. Those greater ian a foot in diameter are blasted and then treated in the same anner. It was found that in the lower heavy ground a duty of only cubic yard per miner's inch was obtained, whereas in the top ground, here the wash is regular and bowlders not abundant, a duty of 3 ibic yards per inch could be expected. The gold is for the most art fine and assays $14.90 per ounce.

A second pit worked a short distance below the one just described iffers in the character of its bed rock. An area about 350 feet long y 100 feet wide was piped down through an average depth of about) feet, where a clay and cement-gravel bed rock retained the pay. and cleaning was necessary, though the taking up of the bed rock as not deemed profitable.

About 2 miles above the plant just described, at the mouth of Milk ulch, a small tributary of Crow Creek from the northeast, mining as in progress by hydraulic methods the greater part of the season.

In all, about 50,000 yards of gravel were washed from two pits, wit reported satisfactory results. The deposit worked lies in a basi formed by the damming of Crow Creek by a terminal moraine, lef after the retreat of the glacier which formerly occupied its valley. cut through this moraine had been run at considerable expense to ta the bedded deposits lying above it. At the upper pit a giant usin 200 inches of water under a pressure of 240 feet had moved 15,00 yards. The flume from this pit was 3 feet 9 inches deep by 50 inche wide and floored with 8-inch square blocks. The posts and sills wer 4 by 6 inch timber, and the lining boards were 3 inches thick. Th side and bottom boards were made of 1½-inch lumber. A grade of inches in 14 feet was maintained, and the tailings were dumped i Crow Creek. A 5-ton derrick, reported to move 1½ yards a minut was used in removing rock too large to put through the flume. Thirt inches of water under a pressure of 200 inches was sufficient to run th derrick. In the lower pit 25,000 yards was moved in ten days by tw giants equipped with 5-foot nozzles and supplied each with 250 inche of water under a head of 250 feet. Above the upper pit, jutting ou from the mountain side on the northeast, may be seen what appea to be a remnant of the valley filling consequent on the damming c Crow Creek by a glacial moraine. It consists of a ridge of ill-sorte angular material, cemented by a fine rock-flour silt, a condition to b expected where deposition was as rapid as would occur near the hea of a gulch of extremely steep gradient. It is reported that a drift ru into the deposit disclosed prospects of sufficient value to warra mining by hydraulic methods, and it is planned to begin active wor next season.

Mining on Sixmile Creek, which enters Turnagain Arm at the tow of Sunrise, was not carried on with any great activity during 190 but the high benches along its course were worked by individuals wit small outfits at several localities. Work in the stream gravels prop amounted to little. At the forks of Canyon Creek an attempt wa made to reach bed rock by means of a hydraulic elevator. What suc cess attended the work was not evident at the time of visit, as wor had ceased.

Bench claims on Gulch Creek, a tributary of East Fork a short di tance above its junction with Sixmile Creek, produced a sma amount.

On Canyon Creek the most important work was that by S. W Wible. About 50,000 cubic yards were moved during the season b hydraulic methods from a bench claim on the east side of the cree Water, which during the height of the season amounts to 1,000 1,500 inches, is brought through a ditch 4 miles in length. The dit measures 6 feet at the top, 3 feet at the bottom, and is 3 feet dee

It was built at a cost of about 60 cents per cubic yard. Owing to the usual inadequate water supply during the last third of the season, it is planned to build 12 miles of ditch to Summit Lake at the head of Canyon Creek. This ditch, which is now partially built, is 5 feet wide at the top, 3 feet at the bottom, and 2 feet deep. A contract price of $2.50 per rod has been made, which is 10 cents cheaper than the old ditch. Two giants fitted with 4-inch nozzles are used when an abundant supply of water is available. As the water falls, the size of the nozzle is reduced. A yardage of 1,000 cubic yards per day can be maintained at a reported working cost of 4 cents per yard. This figure is exceptionally low, and probably can not be realized without most careful management. The gold-saving apparatus, which is adapted to the precipitous bluff upon which the bench is mined, is a combination of sluice boxes, grizzles, and undercurrents combined in an ingenious manner. A main sluice of four box lengths, with 11-inch grade and fitted with riffles, is terminated by a steeply inclined grizzly over which large rocks pass to the dump. The grade of the grizzly is 5 feet in 16 feet, and the bars are 4½ inches apart. Fitted beside the main sluice are two undercurrents fed by material passing through grizzly bars 3½ feet long and 2½ inches apart. The undercurrents have a grade of 8 inches to 12 feet, are each 6 feet long by 3 feet wide, and are fitted with slot riffles. The material from the undercurrents passes by a small sluice to meet the material which falls through the large grizzly at the end of the main sluice, and with it runs down a second large sluice at right angles to the first. Undercurrents from the second sluice are arranged in a similar way to those above described. A third turn in the arrangement of the boxes brings the wash, now thoroughly cleaned, back to a point nearly beneath the large grizzly at the end of the first sluice. The arrangement is said to be very satisfactory.

On Mills Creek, a tributary of Canyon Creek from the southeast, a small amount was produced. At one point drifting was carried on with reported success.

On Cooper Creek, a tributary of Kenai River 2 miles below its source, benches carrying gold in commercial quantities are reported.

Though no gold was produced the last season on Lynx Creek, a tributary of East Fork 8 miles above its junction with Sixmile Creek, development work of importance was completed. It is planned to work the gravels near the mouth of this creek by hydraulic methods. To reach bed rock and to avoid the thick deposit of coarse wash at the mouth of the creek, upon which sufficient grade for a dump could not possibly be secured, a 600-foot tunnel has been run through a sharp ridge, reaching a point where the valley of East Fork is lower than the bed-rock floor of Lynx Creek. The tunnel is 6 feet high by 5 feet

wide and cost $10 per running foot. By extending a tailrace across this flat, as débris collects, a practically unlimited dump may be obtained. A flume 3 feet wide and 2 feet high, fitted with block riffles, will be used. Lumber, either whipsawed or brought in, costs about $100 per thousand. It is reported that abundant water to work two No. 1 hydraulic giants under a head of 400 feet can be secured by a 1,000-foot pipe line 8 inches in diameter. The gravel bank, of which the greater part may be piped to the sluice, is 25 feet deep and is reported to run 50 cents to the yard. The gold is coarse, nuggets up to $20 and $60 having been found.

COPPER.

KNIK RIVER.

In August, 1906, prospectors reported the discovery of copper in the high mountains between Knik and Matanuska rivers, but this locality was not visited. The ore is chalcopyrite (sulphide of copper and iron) and is associated with pyrrhotite (magnetic iron pyrites). The ledge is reported to be nearly vertical and has been traced through four claims. No actual development work has been done. The ore body is said to be 3 feet thick, consisting of 18 inches of solid chalcopyrite and 18 inches of quartz irregularly cut by stringers of ore. Graphitic gouge matter occurs near the ledge. From the foregoing description it appears probable that the deposit occupies a mineralized shear zone similar to those found in the Prince William Sound region, both in its manner of occurrence and in the bed rock with which it is associated. The mountains between Knik and Matanuska rivers, though difficult of access, are thought worthy of prospecting.

KASHWITNA RIVER.

During the summer of 1906 assessment work was done on copper claims near the head of the north fork of Kashwitna River, a tributary of the Susitna from the east. Samples of bornite said to occur in a granite were seen. The claims are about 120 miles from Knik and 10 miles from timber.

SUNRISE DISTRICT.

A copper prospect located on the west side of Lynx Creek, a southern tributary of East Fork, near the summit of the divide near its head, is being developed by the Ready Bullion Copper Company, of Boston, Mass. The country rock at this locality is a part of the graywacke-slate series composing the central and northern mass of the Kenai Mountains. The dominant cleavage at this point is N. 10° E., a direction nearly parallel with the ridge in which the copper deposit to be described occurs.

At an elevation approximating 3,000 feet a tunnel has been run 350 feet S. 80° W. into the mountain, a direction nearly at right angles to its trend. A drift from a point near the end of the tunnel was driven 150 feet to the south and 90 feet to the north, along a zone characterized by intense slickensiding or shearing in a nearly vertical direction. A short distance beyond this zone a fault dipping 35° W. was observed. Such a dip would not interfere with the continuation of the ore in depth.

Chalcopyrite ore accompanied by pyrrhotite and pyrite with much quartz has been deposited along the zone of shearing disclosed by the drifts. Irregular masses as thick as 2 feet were observed, but their horizontal linear extension was short, the vein fluctuating between 6 inches and 2 feet in thickness. At the south end of the drift the vein was narrow, and at the north end the face did not disclose ore. It was reported that gulches cutting the mountain north and south of the tunnel showed no signs of copper. Stripping, however, had not been done.

A thousand feet below the entrance of the upper tunnel an adit is being driven to catch the ore in depth. A length of 800 feet has now been completed. A rough estimate shows that with continued vertical dip the shear zone would be reached within a distance of 2,000 feet from the mouth of the adit.

THE NOME REGION.

By Fred H. Moffit.

INTRODUCTION.

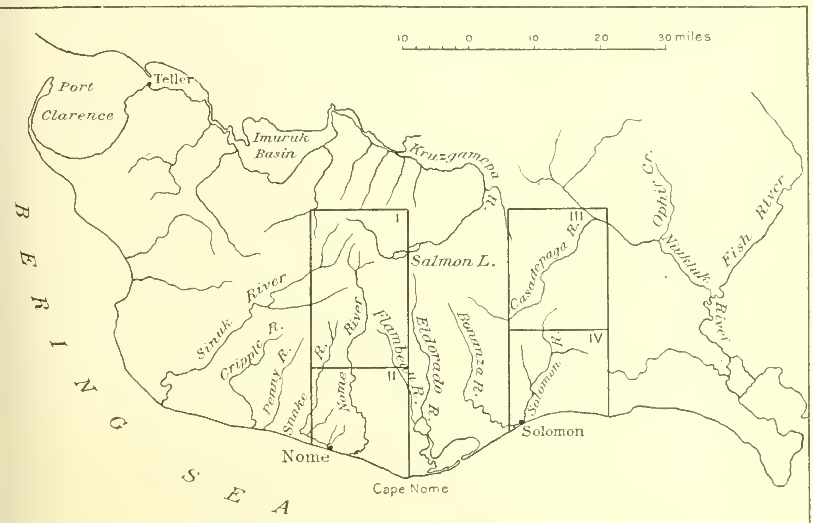
The work of the Geological Survey in the Nome region was initiated by Schrader and Brooks during the year following the gold discoveries on Anvil Creek in 1898. Their investigations, although undertaken in the late fall and prosecuted under many difficulties, nevertheless resulted in the first statements regarding the high bench gravels and the probable presence of other gold-bearing beaches back of the present beach, whose wealth had then just been revealed. It is worthy of note that this prediction [a] has since been fully justified.

The investigation thus begun was continued in 1900. A geologic reconnaissance was carried on by Brooks, and a topographic reconnaissance map, including a large part of the southern half of the peninsula was made by Barnard. Geologic work was again undertaken in the region in 1903 by Collier, but formed only a part of his studies for that year. The field work of these three seasons was of a reconnaissance character and had as its prime object a study of the occurrence and distribution of the gold. Detailed study of the region was made possible when a much more accurate map representing an area which includes the beach from Cape Nome to a point 3 miles west of the mouth of Snake River, a distance of 15 miles, and extends from the coast to the Kigluaik or Sawtooth Mountains, slightly more than 35 miles, was completed by Gerdine in 1904. (See fig. 5.) Field work was begun in the following spring (1905) by Frank L. Hess and the writer and carried to completion during the summer of 1906 by Philip S. Smith and the writer. The chief aim in this work was to secure, as far as possible, the facts throwing light on the bed-rock source of the gold now found in the gravels and to investigate the processes governing the present distribution of that gold.

It is a fact well known among mining men that by far the greater number of gold placer deposits are largely worked out in a comparatively small number of years, and that lode deposits, though they often yield much smaller values in return for the capital and labor

[a] Schrader, F. C., and Brooks, A. H., Preliminary report on the Cape Nome gold region, a special publication of the U. S. Geol. Survey, 1900, p. 22.

xpended in the same length of time, nevertheless tend toward the ermanence and stability of a mining camp. While it is believed hat the gravel deposits of the Nome tundra, as well as the stream nd bench gravels of the district, are sufficiently great in amount and ch in gold content to insure Nome an important place among gold-roducing districts for many years to come, still the discovery of aluable lode deposits can be of no small importance for the inter-sts of the region. The discovery and exploitation of such deposits re not made in most mining communities until the available placer round is largely taken up or until failure of the valuable content ompels capital to seek other investment. It is therefore not to be ondered at that only slight attention has yet been given to lode ining in the Nome region.



G. 5.—Sketch map of southern Seward Peninsula, showing the area covered by detailed topographic maps. I, Grand Central special; II, Nome special; III, Casadepaga quadrangle; IV, Solomon quadrangle.

It is an unfortunate fact that the work of a mining geologist can ot be entirely separated from that of the miner, and that the data e requires for the solution of many problems arising in the exten-on or exploitation of mining properties can be secured only after evelopment has reached a more or less advanced stage, and in many laces only after large sums of money have been expended. We have ere one reason for the distrust in geologists which mining men not nfrequently show. A better realization by both classes of the inter-ependence of interests, which is already becoming evident, is greatly o be desired and must lead to a greater appreciation of what each wes to the other.

It is the purpose of this paper to give a preliminary statement of the more important facts gathered during 1905 and 1906 bearing on the geology and the source and distribution of placer gold in the portion of Seward Peninsula represented by the two topographic sheets known as the Nome and Grand Central special maps. The paper is not complete, since it goes to press too early to permit a thorough study of the data collected. The final conclusions, together with the two maps mentioned, will be published in a forthcoming bulletin of the Survey.

GENERAL GEOLOGY.

The important features of the bed-rock geology of the region were recognized and correctly interpreted by Brooks and Collier. As stated by them, the rocks are chiefly sedimentary, limestones and schists, but in many places have been intruded in an intricate manner by igneous rocks of several kinds, more especially by greenstones and granite or rocks of a granitic character. Brooks referred the sediments to three periods of time and described them under the names of Kigluaik, Kuzitrin, and Nome series.[a] A brief account of these will be given.

KIGLUAIK SERIES.

The oldest known sedimentaries of this region are exposed in the Kigluaik or Sawtooth Mountains and are well represented in Mount Osborn, a short distance north of the northern limit of the area shown on the Grand Central map. The relative age of the beds is known only by their stratigraphic position, for no fossil remains have yet been found in any of the rocks to be described.

They comprise biotite and graphitic schists and limestones, together with gneisses and granite or related intrusives. In Mount Osborn the schist and limestone beds lie in a nearly horizontal position, but on the southern side of the Kigluaik Range they dip rather gently to the south and beneath the younger sedimentaries. This succession of beds was given the name of Kigluaik series.

KUZITRIN SERIES.

A highly irregular series of beds consisting of siliceous graphitic schists occurring along the south flank and east end of the Kigluaik Range was called by Brooks the Kuzitrin series. It has a regular southerly dip and is not found south of the Salmon Lake valley, but is possibly represented by beds occurring on Charley Creek south of Sinuk River. No conclusive evidence was found within the Grand Central area, however, showing that these black schists should be

[a] See p. 83 (footnote *b*) in regard to use of the term "series."

separated from the underlying Kigluaik series, and in fact exactly similar beds are found interstratified with the biotite schists of that series. A doubt therefore arises as to whether these two should be separated.

NOME SERIES.

South of the Salmon Lake and Sinuk River valleys and extending to the coast of Bering Sea is a region of schist and limestone intruded by greenstone, and in the vicinity of Cape Nome by granite, to all of which the name Nome series was given. In general the strata dip to the north in the portion of the region south of the latitude of Mount Distin and to the south in the portion north of that latitude, thus forming a broad synclinal trough on whose axis Mount Distin is situated. The rocks forming this trough are chiefly schists, with limestone in lesser amount. The greenstones cut both of these in the form of sills and dikes. All have been highly metamorphosed. The limestones, which are found most abundantly in the upper part of the Nome series, have been entirely recrystallized and any organic remains they may have contained are now seemingly obliterated. The original argillaceous sediments, more highly developed in the lower portion of the series, and the greenstones intruded in them are also recrystallized and possess a well-developed schistose structure. The schists may be described freely as micaceous, feldspathic, or graphitic in character according as the minerals mica, feldspar, or graphite are prominent. The micaceous schists, in places highly siliceous, are usually green or silvery gray in color; the feldspathic schist is green, though this color is partly hidden by the development of numerous small feldspar crystals; the graphitic schists are black, becoming gray as the amount of carbonaceous matter decreases and quartz becomes more evident. The feldspathic schists are in many places conspicuous by reason of the abundance of small albite crystals, which are especially noticeable on the weathered surface. They are derived in part from original sediments, but probably in the main from intruded greenstones.

Greenstones are more common as sills than as dikes and are usually highly altered. In general their conspicuous minerals are chlorite and albite, but in some localities they are filled with red garnets. Like the feldspathic schists, into which they grade locally, they are more abundant on the east side of Nome River than on the west and are perhaps most highly developed in the area between Osborn Creek and Nome River.

Only one notable area of granite is found within the Nome series in the region under consideration. It is seen in the two ridges running northward and northwestward from Cape Nome. This granite,

however, does not appear to extend north or west of Hastings Creek, and the entire area occupied by it within the boundaries of the district mapped on the Nome sheet is about 6 square miles. East of the boundary the granite area is probably slightly larger.

STRUCTURE.

It has been stated that the Nome series forms a broad synclinal trough, with an approximately east-west axis, extending from the coast of Bering Sea to the Kigluaik Mountains. There is, however, abundant evidence of an earlier deformation, due to forces acting almost at right angles to those which gave rise to the broad east-west folds and producing other folds much more intense in character and with axes running from north to south or from north-northwest to south-southeast. Yet, in spite of these deformations, it was found that the bedding of the sediments and the cleavage or schistosity are nearly everywhere the same, although exceptions are known.

The Nome series has been deformed under conditions of comparatively light load, as a result of which the strata are much broken, locally with more or less displacement. In places the limestones especially appear to have been crushed, much as a marble block is sometimes crushed under a heavy weight, but on a far greater scale. Faulting of lesser degree is exceedingly common, but direct evidence of large displacements is hard to secure. This is due to the difficulty of finding any reference beds and the well-nigh hopeless task of correlating strata in different or even in neighboring parts of the field. Evidence of faulting is most readily obtained in localities where limestones are present. It is rarely the case that one can actually place hands on the contact of faulted beds, and the displacement is usually indicated by an offsetting of outcrops or the abrupt termination of beds along their strike.

VEINS.

Deformation and rupture of the series has given opportunity for the circulation of mineral-bearing solutions and the deposition of veins of quartz and calcite. Quartz occurs principally as lenses and stringers in the schist, but also as well-defined veins cutting the schist. Veins of white quartz of considerable thickness—10, 12, or even 20 feet—occur, but in no observed case do they show as great mineralization as some of the smaller veins. In several localities prospect holes or short tunnels driven in the large quartz masses show them to be much broken and faulted, and, while the weathered surface is milky white, joint planes and cracks are stained with iron oxide.

Small quartz veins, though less conspicuous, are far more numerous and, as noted, are here and there well mineralized. They appear as small lenses, either lying in the cleavage or crossing it, as filling along

joint planes, and as narrow veins of fairly regular thickness but small longitudinal extent—that is, much flattened lenses. A broken surface of such a vein may show sulphides, generally pyrite, or more commonly a cavernous interior filled with iron oxide derived from the alteration of pyrite. Some of these veins are known from numerous assays to carry gold in small quantity.

Calcite veins are almost restricted to the limestone areas, or at least to these areas and their immediate vicinity. They reach thicknesses of several feet at various exposures, but like the quartz veins have not been found to continue horizontally for any considerable distance. It should be stated, however, that the lack of outcrops, due to the covering of loose weathered material or of moss, is a serious obstacle confronting the prospector who attempts to trace veins in this region, and makes it quite impossible without much labor and expense to determine their extent on the surface.

Numerous calcite veins are exposed in the limestone area of Anvil Mountain and its continuation east of Dry Creek. Prospect holes have been sunk on some of them and many have been staked as mining property. Free gold is found in small amount in some of these veins.

Besides the veins of quartz and calcite described above there are also veins made up of quartz, chlorite, and albite. These were observed most frequently in the Anvil-Newton Peak area.

No well-defined belt of mineralization has yet been established. There are restricted areas, nevertheless, where such secondary deposits are more highly developed than in the remaining parts of the region. The most important of these includes the upper portion of Anvil and Dexter creeks, the lower part of Glacier Creek, and a portion of Snake River extending north from Glacier Creek. Excavations on the third-beach line have shown that there also much of the schist bed rock is filled with small mineralized quartz veins. In this connection it may be stated that north of Rock Creek and on Pioneer Gulch gold is found in the surface débris, where concentration is due to decomposition of the bed rock and removal of the lighter material, the heavier constituents of the rock being left almost in place, since their movement is chiefly downward rather than in a lateral direction. In both places the bed rock is known to contain small mineralized quartz veins, and north of Rock Creek they carry sufficient gold to lead to some attempt at development. No unquestionably igneous rock bodies are known in this disturbed area. The greenstones either do not occur in any considerable amount or their identity is lost through alteration. One small exposure of greatly altered siliceous rock north of Specimen Gulch was at first considered to be an acidic granite, but there is much doubt concerning it.

Brooks (p. 25) emphasizes the fact that many of the most important placer deposits of the peninsula are found in localities where both

schists and limestones occur. In accounting for this he points to the contacts of different kinds of rock and the immediate vicinity of such contacts as loci of maximum weakness and greatest adjustment when the rocks are subjected to disturbing forces, as a result of which a freer circulation is there possible for mineral-bearing waters. This relation has been brought to the attention of the writer also by mining men in Nome and should be kept in mind by prospectors, since such contacts are favorable localities. Heavy limestones are found in the southern part of the mineralized area of Anvil and Glacier creeks, and thinner beds occur in the ridge between the two streams. To the northwest, however, their number decreases, and here some of the greatest mineralization is seen. It does not appear, then, that in this last-named place the presence of limestone was essential to the formation of mineral deposits. In fact, it would be difficult to prove that the limestone-schist contacts to the southeast are more highly mineralized than the schists themselves, but the occurrence of nearly all the placer-gold deposits of the peninsula in such areas suggests the relationship mentioned. Buster Creek affords a good example of a disturbed limestone-schist area where small secondary quartz deposits are numerous.

UNCONSOLIDATED DEPOSITS.

GENERAL DESCRIPTION.

Unconsolidated deposits may here be divided into two classes—those which have undergone a sorting process and deposition in water and those which have not. To the first class belong present stream and lake gravels, bench gravels, and the gravels of the Nome tundra to the second, the loose débris mantling the slopes of hills and derived from the decomposition and weathering of the rock beneath or on the slopes above, together with part of the morainic material resulting from glacial action.

In by far the greater number of small streams the gravels consist o material like that of the hills surrounding the valley and appear to b entirely of local origin—that is, they are derived from bed rock in th drainage basin where they now lie and within a comparatively shor distance of their present location.

In the larger streams, such as Nome, Snake, Stewart, and Sinul rivers—that is, in streams heading toward the Kigluaik Mountains—together with a few of their tributaries, and in the Nome tundra a con siderable portion of the gravel is derived from a more distant source and its distribution is such as to indicate that part of it was laid dow under conditions different from those prevailing at the present time.

Rounded granite bowlders derived from some source in the Kigluai Mountains are found in Sinuk and Stewart River valleys, along Snak River, on Anvil and Dexter creeks, along Nome River, and at variou

other localities at elevations as great as 800 or 900 feet, 1,400 feet in one place, above sea level. Such foreign fragments are rare if they occur at all in the deep elevated gravels at Dexter station, on the Nome Arctic Railway, but are numerous in the surface gravels at the head of Grass and Specimen gulches. They are often seen in the gravel deposits of Nome tundra, both at the surface and in the old beach deposits, where the fragments appear to be smaller and perhaps more rounded and weathered than those above. It is probable that much of the granite in the old beaches was brought by ordinary stream transportation or was carried along the shore from such localities as Cape Nome by the surf and ocean currents, and that most of the large surface bowlders were brought to their present location through the agency of ice, though in some places their position and quantity are such as to make it appear doubtful whether transportation by floating ice offers a complete explanation of their presence.

An examination of the deposits in the field therefore confirms the opinion concerning the character of the stream gravels which one would reach by a study of the maps alone—namely, that the gravels of the large southwestward, southward, and southeastward flowing streams show a greater variety of material than is seen on the smaller tributaries whose loose deposits are of more local origin. The fact which it is desired to bring out, however, is that on these small streams most of the gravels were laid down under present-day conditions such as will not account for the peculiarities and position of much of the gravels along the larger streams and of the elevated gravels. Two explanations have been suggested to account for such gravel accumulations as are found on the divides at the head of Dexter Creek, which in the saddle at Dexter station have a thickness of 135 feet. The first is that they are remnants of an extensive gravel sheet deposited at a time when the land had an elevation at least 600 feet lower than now and when the drainage systems may have been quite different. The second would account for their presence by considering them to have been deposited when the main stream valleys were occupied by glacial ice and the waters were ponded in some of the tributary streams. It does not seem possible, with the present knowledge, to say definitely that these gravel deposits are to be ascribed wholly to either cause, and it is not impossible that both conditions may have prevailed in some degree. The bed rock and pay streak at Dexter station, however, are such as to make it appear probable that the gold there was deposited by a southward-flowing stream or streams, since two well-defined stream channels at slightly different elevations lead from the head of Nekula Gulch through a bed-rock depression on the south toward Deer and Grouse gulches.

TUNDRA GRAVELS.

The Nome tundra gravels occupy the crescent-shaped lowland extending from Cape Nome to the hills west of Cripple River (see fig. 6), about half the area being within the boundaries of the district shown on the Nome special map. The tundra deposits were laid down in part by ocean currents and in part by streams, and consist of silt, interstratified fine sands, well-rounded gravels, and beds containing angular fragments and blocks up to 2 feet or more in greatest diameter. These large pieces are usually flattened slabs of schist, more rarely limestone. Large bowlders of granite, worn

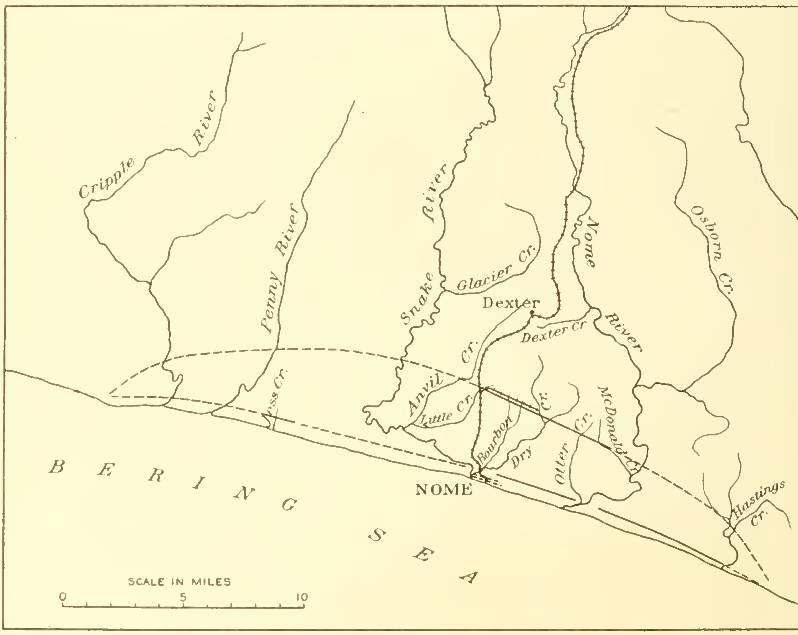


FIG. 6.—Sketch map showing the known parts of the second and third beaches (full lines) at Nome and their hypothetical continuations (dashed lines). The upper line also shows approximately the area of the Nome tundra.

and more or less rounded, are found on the surface, but were not observed in the coarse material below. Flattened and striated fragments of limestone are also found near the surface.

Our knowledge of the tundra has been greatly increased during the last two years by developments on the buried beaches. Two well-defined ancient gravel deposits of this sort have now been explored through a part of their length. (See fig. 6.) One of these near Nome, lies about three-fourths of a mile north of the present coast line and extends eastward to a point within a short distance of Cape Nome. At Hastings Creek it is about a fourth of a mile distant from tide water, but east of that locality its position is not

known, and it appears to have been removed through erosion. To the west it is probably represented by the beach deposits of Jess Creek. Its elevation above sea level is 37 feet and its location is in most places indicated by a steep moss-covered gravel bank at whose foot it lies. The other beach line is definitely located from the place where it is crossed by the railroad tracks at Little Creek to McDonald Creek, a distance slightly more than 5 miles. Its elevation above sea level, according to reliable information obtained at Nome, is 79 feet. It extends in a nearly straight or slightly curved line between the points mentioned, yet shows slight undulations and is interrupted by the valleys of Nome River, Anvil Creek, and Snake River, these streams lying below its level. These two ancient coast lines are generally known as the second and third beaches, the present one being regarded as the first. Mention of others lying between is frequently heard, but although this is not only possible but even probable, no other continuous beach has yet been traced.

A generalized section of the deposits exposed along the third beach would show gravel or sandy gravel with coarse bowlders resting either on schist bed rock in which are a few limestone beds or, as is the case at the east end of the beach, on fine sands which in turn rest on schist bed rock. Above this is a considerable body of gravel overlain by "muck" and the surface vegetable matter. This general section is, however, subject to wide variations. The thickness of the muck varies from 1 or 2 feet to 20 feet or more. Underlying the muck in several shafts a blue clay was found. In places a heavy wash occurs near the surface. Here and there the gravels are slightly cemented by the deposition of lime or iron oxide. Marine gravels are interbedded with creek wash. The character of the material varies both in composition and in coarseness—in fact, the deposits where first exposed on Little Creek were so varied in appearance and manner of deposition as to cause doubt whether any of them were of marine origin.

The gold-bearing gravels or pay streaks vary in width from 25 to perhaps 100 feet and have a fairly constant southerly slope of about 1 foot in 10. They rest in some places on bed rock, in some places on other gravel, and toward the east, as has been stated, on fine sand.

Only a part of the shafts on the second beach have been sunk to bed rock, as the pay streak usually lies on a false bed rock of clay or sandy clay and gravel. There are few data, then, on which a complete generalized section could be based, but it appears that, though coarse angular material is by no means lacking, it is not as abundant as on the third-beach line. Furthermore, the quantity of garnet, or "ruby sand," is far greater on the second beach and the proportion of other sand and fine gravel is also greater. This is probably accounted for by the fact that much of the material of the third

beach has traveled a shorter distance from its source and has been less subject to stream and wave grinding.

In the third beach, then, irrespective of any greater differences which may have occurred in the meantime, we have definite proof that the land now stands not less than 79 feet higher than it did when the beach formed the coast line. Further evidence of elevation, though of lesser amount, is furnished by marine shells taken from various shafts between the second and third beaches. Such shells in an almost perfect state of preservation are found on Center Creek and suggest that in that locality they accumulated in comparatively quiet water. They occur in gravels 32 feet below the surface and at an elevation of about 20 feet above sea level. Numerous marine shells from Otter Creek were obtained at approximately the same height above sea but at a depth of 50 feet below the surface. They are in a good state of preservation.

As a rule the deposits of the beaches and of the tundra in general are frozen from top to bottom, but there are places where this is not the case. One such area is located near the intersection of the third beach and Holyoke Creek and has caused difficulty in working the Bessie Bench claim because of the large amount of water circulating through the gravel. The boundary between the thawed and frozen ground was here located by drilling, and care was taken not to bring the workings too close. Thawed ground is in some places overlain by frozen ground and here and there is underlain by it also. The reason for the presence of unfrozen areas is not entirely understood, but they are probably due in part at least to the circulation of water through the gravel.

These old beach lines indicate periods of temporary stability in an intermittently advancing or retreating coast line. It is possible that they mark the limits of encroachments of the sea at different periods, since in the case of the beaches mentioned the sea at the time of their formation was cutting fragmental deposits previously laid down. It is evident that if a sea floor gently sloping away from the land were gradually and uniformly raised, the beach line if affected by the elevation only would slowly move seaward, and that the beach deposits would be continuous from the time when elevation began till it ended. Such does not appear to have been the case on the Nome tundra.

The coast was not raised uniformly, and the upward movement may even have been interrupted by periods of depression. Nor are the tundra accumulations due to the work of the sea alone. Rivers and ocean both took part. Such streams as the Nome and Snake were already well established and spread their loads of loose material over the marine sediments at their mouths, carrying the shore line seaward and building up the lowland deposits. It seems probable, too, that

conditions such as prevail along the southern coast of Seward Peninsula to-day may have existed in the past and that the formation of lagoons shut off from the sea by sand bars, as may be seen east of Cape Nome and on a much smaller scale at localities like the mouths of Derby, Little Derby, and Cunningham creeks, may have taken place, and that these lagoons by subsequent filling may have played an important, though not the only, part in the construction of the Nome tundra.

This idea of the formation of the ancient beaches implies that the land formerly stood at a lower elevation, but it is also evident that it once had a greater elevation, for the rock valleys of Nome and Snake rivers are lower than the third-beach line at the places where they are crossed by it, and are even below the present sea level. The rock floor under the present beach also may have been above sea level when it was produced; it was surely little if any below it.

The formation of either of the old beaches was only an incident among the various changes which finally gave us the tundra as we see it to-day. A repetition of the same succession of events that led to the burial and preservation of the second and third beaches would in time add the present one to the tundra's treasury. From the geologist's standpoint these deposits are neither unique nor unusual. The concentration of heavy minerals by ocean waves is a commonly observed phenomenon, and it is only the value of the concentrated material which in this case brings the deposits to notice and makes them remarkable.

GLACIATION.

One of the difficult problems of the region is to discover what effect the action of glacial ice has had in modifying the former topography and in transporting loose material. That the upper valleys of nearly if not all the streams flowing south from the Kigluaik Mountains, as well as some of the tributary valleys of Grand Central River and Salmon Lake, have been occupied by ice masses in very recent time is beyond question. The morainic deposits at the head of Nome River indicate that at least the upper portion of that valley was occupied by ice, and several of the eastern tributaries of the river have well-formed cirquelike amphitheaters at their upper ends. There is no evidence available to show that the peninsula, or rather the southern portion of it, has ever been covered by an ice sheet. On the other hand, all the evidence seems to oppose that idea if our conceptions concerning the rate of rock weathering are correct. The occurrence of monumentlike rock masses, due to weathering, on the hilltops or slopes is one of the noticeable features of the region, and it seems extremely improbable that they could have withstood the advance of moving ice or that they could have been formed since the

disappearance of such ice unless it was present at a time very much earlier than the recent glaciation mentioned above.

Closer study of the region, however, especially of the distribution of gravels, has led to the observation of phenomena which are most easily explained as being due to ice action, and it may be that in valleys like that of Nome River ice streams from the Kigluaiks approached much nearer the coast than has heretofore been supposed. Since the evidence against a mantling ice sheet appears to be conclusive, it is altogether improbable that the tundra deposits have been affected in more than a minor degree by glacial ice except in the form of floating ice, for there are no known centers of local accumulation near the coast.

ECONOMIC GEOLOGY.

The progress in mining on Seward Peninsula has been presented from time to time in various publications of the Survey, and since this present form of report was adopted an account of each season's work has been published yearly. The economically important deposits may be divided into two classes—lode and placer deposits.

LODE DEPOSITS.

Some generalizations concerning the occurrence of veins have already been given and it now remains to describe in greater detail a few particular localities which have attracted some attention during the last year.

BISMUTH.

For a number of years bismuth has been known to be present on Charley Creek, a tributary of Sinuk River from the south. It was first found in the sluice boxes at the lower end of the creek, and later the float was discovered farther up and traced to its source. On the east branch of Charley Creek, at a point about 1,000 feet from the forks and at an elevation of 950 feet above sea level, two parallel quartz veins appear near the stream bed and have been found to carry the bismuth. These veins are about 12 inches and 8 inches in thickness and are separated by 16 to 18 inches of schist. They occur in strike joints dipping 50° to 60° N., and may be traced on the surface for only a short distance because of the covering of loose slide rock. At one place they are offset about 8 to 10 inches by a small fault. The percentage of bismuth seen in the veins is small, but some bowlders found in the stream below show a larger amount. Attempts to interest capital in the development of these veins have not been successful and up to the present time little has been done toward prospecting them.

ANTIMONY.

A quartz vein carrying the sulphides of iron and antimony was lately found on Manila Creek. The vein is located on the hill slope west of the upper end of the creek and as traced by surface float has a length of about 3,000 feet. It has an elevation above sea level of approximately 800 feet at its southwest end and 1,200 feet at its northeast end. Apparently it dips at a moderate angle toward the northwest. The thickness is not known, since at the time it was visited by the Survey party no exposure of the vein in place had been made and all information concerning it was derived from loose material on the surface, part of which may of course be considerably removed from its source. Pieces of the float, however, indicate that locally the vein reaches a width of 2½ feet, but that its average width is much less, probably about 8 or 9 inches. The best ore occurs as bunches or irregular streaks through the quartz and usually shows the reddish color resulting from partial oxidation or a stain of iron oxide. A prospect hole, supposedly on the dip of the vein, has been driven for a distance of 60 feet into the hill, but the vein was not visible at its lower end. The hole was located in loose surface material and schist bed rock considerably broken and so much displaced that it was not possible to make any reliable observation on the ore body. Besides antimony the vein carries some gold.

GOLD.

As yet no gold-bearing veins of proved value are known in the Nome region. The occurrence and character of quartz veins have been previously described, together with some general statements regarding them, and it was pointed out that the more highly mineralized veins are the small ones such as are numerous in the schists of the Anvil-Glacier Creek divide or the region north of Rock Creek. There was some prospecting on gold-bearing quartz veins in this vicinity during the summer of 1906, principally on the west side of Anvil Creek, above Specimen Gulch.

GRAPHITE.

Graphite occurs abundantly in portions of the schists included in both the Nome and Kigluaik series, but is not known in commercial amounts within the area covered by the Nome and Grand Central sheets. Just north of the Grand Central area, however, in the upper valleys of Grand Central River and Windy Creek, and especially in the vicinity of the divide between these two streams, there are graphite deposits of considerable size. Their occurrence, as well as that of the graphite to the west of Cobblestone River on the north side of the Kigluaik Range, has been known for a number of years, but so far no effort has been made to develop them.

Rising to the south from the saddle between the Grand Central and Windy Creek is a sharp ridge made up of biotite schists striking east and west and cut by dikes and sills of intruded coarse granitic rocks. Some of the schists are highly graphitic, the graphite appearing as abundant small scales on the cleavage surface and much of it not distinguishable from the biotite on casual examination. Locally graphite is segregated in beds of much flattened lenticular masses lying in the cleavage of the schist and reaching thicknesses of 6, 8, or even 18 inches. Thin beds of schist with numerous large garnets are included and quartz is nearly everywhere present. When compared with the higher grades of graphite the raw product of this locality is seen to have a much greater weight, owing to the included quartz.

As stated, the biotite schists are cut by sills and dikes of pegmatite. These also contain graphite, which is associated with them in such a way as to suggest that the intrusives and the graphite are closely related. Graphite seems to be an original mineral in the pegmatite and also occurs in close association with it in the schist. At one place about 8 inches of solid graphite was included between a pegmatite sill and the overlying schist. The steep slopes of the mountain are strewn with the loose fragments, which, owing to the fact that they are much lighter than either the schist or pegmatite, appear more abundantly on the surface. One block with dimensions of approximately 7 feet, 6 feet, and 30 inches consisted of about equal thicknesses of schist and apparently almost pure graphite.

These graphite-bearing schists extend eastward beyond the east fork of Grand Central River and westward across Windy Creek and the head of Cobblestone River to the region south of Imuruk Basin, where, if the reports of it are true, the graphite is present in greater quantity than in the locality just described.

The quality of this graphite is such as to prohibit its use where the better grades are required, although it might be of value for some purposes. With the present price of the mineral, however, it is doubtful if it can be now handled and placed on the market with profit.

PLACER DEPOSITS AND MINING.

To those who year by year have followed the development of mining in the region adjacent to Nome it is a noticeable fact that during the summer of 1906 the attention of mining men was largely given to operating within the area of the Nome tundra. This is a condition which may probably continue for some years, until the gold of the beaches begins to fail or until all the available ground is opened up. If, in addition to the operations on the tundra, those of Glacier Creek, Anvil Creek, and Grass Gulch are included, all the most important workings will have been taken into account, although elsewhere within the area shown on the Nome and Grand Central maps minor

operations were conducted on a few scattered streams, probably the most extensive being on Buster Creek.

At present the buried beaches of the Nome tundra occupy the center of the mining stage, and the efforts of all operators have been given to the exploitation of old placers or the search for new. Litigation touching the rights of property, however, has seriously obstructed the development of much of the most valuable ground, and may be expected to continue to do so as long as the present methods of acquiring and holding mining property are in force.

Mining is carried on most actively just now along the two ancient shore lines whose locations and principal features have already been described, but there has been more or less work on different streams, such as Dry and Bourbon creeks, and extensive drilling in various other parts of the tundra. On the first or present beach practically all work was suspended. Along the second beach many of the old properties were worked and some very good new ground was discovered in the vicinity of Otter Creek. The third beach is the principal producer of the region.

The third beach was discovered in the late fall or early winter of 1904, but when the summer closed in 1905 operations were confined to

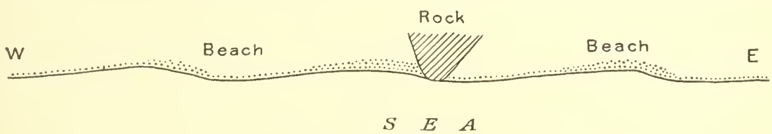


FIG. 7. Diagram showing the manner in which gold is concentrated north of Nome in shallow depressions or on sides of cusps of the third beach.

the immediate vicinity of Little Creek. An account of this locality has been published elsewhere.[a] During the winter of 1905–6 the eastward continuation of the beach was located to a point within a short distance of Nome River. Between Moonlight Creek or the railroad and McDonald Creek it is traced continuously. To the west and east of these localities it is not definitely known. Remarkably rich ground was exploited near Little Creek and between Holyoke and Bourbon creeks, and nearly all the claims between Little and Dry creeks have shown good values in gold. East of Dry Creek less work has been done, but most of the shafts have struck good pay. Nevertheless, some claims or parts of claims are of little value with the present cost of mining, for while the beach gravel deposits are continuous the pay in them is not so. There are intervals along the line where gold is present in small amount or is almost lacking. These places are sometimes referred to as "blanks." Further, the gold is not evenly distributed through any of the gravel. The writer was informed that in the shallow depressions such as occur at intervals along the beach a much greater concentration of gold took place on the east ends (see fig. 7), and that

[a] Moffit, Fred H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 134.

in one or two places where low ridges or rolls of bed rock reached the surface and projected slightly beyond the ancient beach exceptional amounts of gold were found on their west sides, a position of maximum concentration corresponding to that in the indentations just mentioned. This would indicate that the distribution of gold in the gravels was largely influenced by the prevailing direction of the ocean waves and currents. It is probable also that very rich deposits, such as occur at Little Creek and Bessie Bench, are due to their nearness to the source of gold or to streams which brought it to the sea. The character of both the gold and the gravel accumulations would indicate the same thing. On the western part of the beach the gold is, on the average, much coarser than at the east end, where it resembles in appearance and approaches in fineness that of the present beach. The gravels of the west end are more variable in character and exhibit a larger amount of coarse angular stream wash than those toward the east, showing that the conditions under which the western gravels accumulated were less uniform—at one time stream deposits, at another sea deposits, being laid down.

Some ideas concerning the eastward and westward continuations of the third beach are suggested by an examination of the topographic map. The shore line must formerly have extended from the hills west of Cripple River to Cape Nome, and if one may judge by the portion now known it had the form of a broad arc of fairly uniform curvature, like the present beach, but with smaller radius. It is the belief of not a few miners at Nome that the third beach did not, like the first and second beaches, keep to the seaward of Cape Nome, but that it passed to the north through the broad, low depression between Saunders Creek and Flambeau River, thus forming an island of the Cape Nome granite area. The elevation of the depression between Cape Nome and Army Peak is only 115 feet, and the possibility of the cape being an island at the time when the third beach was formed can not be refuted by any evidence now at hand, although it appears improbable. Bed rock is traced northwestward from Cape Nome for a distance of nearly 5 miles, and in the low rounded hill between Hastings and Saunders creeks has an elevation of 297 feet. Between this point and the Army Peak schist mass, still farther to the northwest, is an interval of about 3 miles across a broad, low saddle where no rocks are exposed. As stated, the elevation of this flat at its lowest point is about 115 feet, but the depth of gravel is unknown. If it has a thickness of 40 or 50 feet it is possible that the third beach passes through. It seems far more probable, however, that the controlling influence in determining the coast line here was exercised by Cape Nome, since it must have been a factor in directing the ocean currents and consequently the accumulation of sands and gravel. To judge

from present conditions, it appears more likely that the sea would have built a connecting bar between Cape Nome and Army Peak rather than wash between them. At any rate, the force of the waves due to southerly and southeasterly winds would have been greatly diminished through the protection offered by Cape Nome, and the amount of concentration would have been thereby decreased.

Another idea which is maintained by some and may lead prospectors astray is that wherever bed rock can be found at an elevation of 79 feet above sea level the third beach will be present. The fallacy of this idea is immediately apparent when it is remembered that, so far as known, the old beaches were not laid down on a cleanly swept, somewhat uneven rock floor, but were formed over a surface whose inequalities had already been reduced by a filling of gravel and sand. This is shown by the fact that in many places they do not rest on bed rock, but are underlain by a variable thickness of loose deposits.

Further evidence of a somewhat negative character is afforded by the fact that neither the third beach nor either of the others is known to have formed reentrants at such places as their intersections with the valleys of Snake and Nome rivers, but rather that in each place where the river valleys lie below the beaches at such intersections the beaches end abruptly, for the present valleys through the loose deposits have been cut since the beaches were formed.

Another fact which must not be lost sight of in prospecting for the third beach is the possibility of recent warping. When formed, a beach is at sea level, and if raised uniformly throughout its length all parts will continue to have like relations to the sea. But changes of level do not always nor even usually take place in a uniform manner throughout all portions of an affected area. One part may be raised or lowered more than another, or one part may even be raised while another is sinking. It does not follow, therefore, that because one point of the beach has an elevation of 79 feet all other parts will have the same elevation, although in a small area such as this it is probable that they will not differ greatly.

Since, however, we now have no evidence that warping of any consequence has taken place, and since so far as we know it the third beach does maintain a fairly constant level, it is not to be expected that it will be found in any locality whose surface elevation is less than 75 or 80 feet above tide, even if such an area lies directly between or in line with points where it is known to be present.

Some probabilities concerning the distribution of gold in the known beaches or in others which may be found are gained from a consideration of its distribution in the gravels so far exploited. The richest gold-bearing gravels mined in the Nome tundra have been found in that portion of it which lies between Nome and Snake rivers. This

corresponds also with the richest part of the first or present beach whose greatest values were taken from the neighborhood of the mouth of Snake River and from sands to the east toward the mouth of Nome River. This area lies directly south of the mineralized area from which it is believed that the gold has been chiefly derived, and it is the locality toward which weathered material from the near-by hills may properly be expected to migrate, since it lies immediately between them and the sea. There appears, therefore, to be warrant for the assumption that in the future, as in the past, the most valuable placers will be found within the limits given. One apparent exception is to be noted in the old beach placers of Hastings Creek. There is a possibility, however, that these may be the result of more than one concentration, that they may contain the gold of several old beach lines converging toward Cape Nome, and that the gravels from which they were derived may not originally have carried any very notable amount of gold.

GENERAL DEVELOPMENT.

Some improvements affecting in greater or less degree nearly the entire region were carried on during the summer and merit notice. Among them is the extension of the railroad formerly known as the Wild Goose, later as the Nome Arctic, and now as the Seward Peninsula Railway. In 1905 this road was extended from a point east of the summit of King Mountain into the low saddle north of it, near the part of the Miocene ditch known as the "Ex." In 1906 the road was continued northward and eastward through the valleys of Nome River and Salmon Lake and thence down the east side of Kruzgamepa or Pilgrim River. When the Survey party left Nome in October the roadbed was completed and the tracks were laid nearly as far as Lanes Landing, on Kuzitrin River. During the coming summer (1907) the road is expected to reach Kougarok River, thus opening for development a region which to this time has been one of the most difficult of access on Seward Peninsula.

The construction of the Seward and Pioneer ditches, which were begun in 1905, was carried forward in 1906, so that now both deliver water on the tundra north of Nome. The Seward ditch, the upper of the two, has an elevation of about 275 feet on Dry Creek. The Pioneer ditch is about 60 feet lower. There are, then, three ditches, the earliest being the Miocene, which supplies water on Glacier, Anvil, and Dexter creeks, bringing water from the upper Nome River drainage area to the vicinity of Nome.

A wood-stave pipe line to carry water from upper Grand Central River into the Nome River basin is under construction by the Wild Goose Company. The greater portion of the trench in which the

pipe is laid between the intake at Crater Lake and the Nome River-Grand Central divide is completed and about 1 mile of pipe put together. Part of the material for the remainder is on the ground, and more is being taken in this winter (1906–7). This line, if carried to Nome, as is now intended, will furnish water with greater head than any of the ditches yet constructed.

Construction work on the power plant at the outlet of Salmon Lake was interfered with by litigation between rival claimants for the dam site and water supply, but will doubtless be taken up again as soon as the question of ownership is settled.

GOLD FIELDS OF THE SOLOMON AND NIUKLUK RIVER BASINS.

By Philip S. Smith.

INTRODUCTION.

While the area drained by Solomon River and the Niukluk and its tributaries was visited by the writer for only a few days, it has seemed desirable to make a brief statement of some of the more important developments that have been under way since the progress report for 1905 was published.

SOLOMON RIVER BASIN.

DREDGING.

In the Solomon River region few new developments were in progress. The most active work was being conducted at the dredge near Rock Creek and at the Big Hurrah mine. Outfits of one to ten men have been engaged along the river and its main tributaries, but last summer was so dry that most of the smaller operators could work only intermittently.

The dredge on Solomon River has previously been fully described.[a] During the last season work has gone on uninterruptedly and, as far as could be learned, in a manner highly satisfactory to the owners. Much ground has been handled at a low cost. The dredge seems to be efficient in cleaning gold from the bed rock. This was a matter of a good deal of importance when the availability of a dredge was first discussed and is one of the vital points which should be thoroughly considered by anyone who contemplates undertaking dredging operations. Too much emphasis can not be placed on the preliminary investigations which should always precede the construction of a dredge, since the neglect of these considerations has often resulted in financial failure. It is not only necessary to have efficient management, but it is also of prime importance that the ground should be thoroughly prospected before a dredge is built. A dredge is

[a] Moffit, Fred H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, pp. 136–137.

very costly machine, and unless an area of sufficient size and richness to repay the cost of the dredge and pay interest on the investment is obtained it is better not to consider this form of mining. It may seem a waste of time to state so self-evident a fact, but the number of abandoned dredges which have not paid for themselves in different parts of Seward Peninsula bears ample testimony to the neglect of this most simple precaution.

LODE MINING.

Work at the Big Hurrah mine on Big Hurrah Creek has continued during the past year on practically the same scale as formerly. No new developments had occurred at the time of the writer's visit. This mine still continues to be the only productive lode-gold mine in the entire district. About forty or forty-five men are employed at the mine and at the stamp mill, which is close to the mine.

PLACER MINING.

During the winter of 1905–6 work in the Solomon River region was carried on much more extensively than during the previous winter. It was recognized that the lower wages paid during the winter, coupled with the fact that the walls in deep gravel cuts stand better than when the frost is out of them in the summer and caving takes place, allowed the most economical development of many of the properties. From reliable sources it has been ascertained that approximately forty men were employed on Solomon River and its tributaries during the winter of 1905–6. Though no accurate figures could be obtained, it is estimated that about $75,000 was taken out during the winter. The figures for the production during the last summer are too vague to permit even an approximate statement.

NIUKLUK RIVER BASIN.

The areas in the Niukluk basin in which minerals of economic importance have been worked during the last year may be described according to their geographic position on the different tributaries of the river. The main productive tributary streams from the mouth of the Niukluk toward the head are Fox River, Melsing, Ophir, Goldbottom, and Elkhorn creeks, and Casadepaga River.

BENCH GRAVELS OF THE NIUKLUK.

In the whole region there are practically no winter mines, and this has a very detrimental effect on the growth of the district. The miners are driven to some of the other camps which offer winter work; and those who are faithful and industrious are retained in the field to which they have gone, and only those of lesser ability drift

back, after the break-up, to the summer work in the Niukluk regio This criticism applies only to the laboring men and is not intende in the least to reflect on the prospectors and miners who are develo ing their own ground or holding responsible positions with any the larger companies.

To meet this annual exodus many of the more foresighted busine men are attempting to develop winter workings which shall gi employment to a more permanent population. Explorations wit this end in view are being carried on in the deep gravels that occ along the Niukluk between Ophir and Camp creeks. This work h not progressed sufficiently to prove the value of the ground, but fro the returns so far obtained further outlay is justifiable. During t last summer two men sunk a shaft 40 feet through these gravel A section of this shaft is of interest not only as giving the successio of sands and gravels, but also as indicating the frozen condition The ice, on melting, so undermines and caves a shaft that its preserv tion during the summer is extremely expensive. The section in t shaft is as follows:

Section of bench gravels on Niukluk River between Ophir and Camp creeks.

	Fee
Vegetation and muck	2
Pure ice	1[illegible]
Sand and ice	1[illegible]
Rock fragments, etc.; much mica	
Sand and ice	[illegible]
Frozen gravel, carrying values	1[illegible]

Up to the close of last summer no rich pay had been found in t benches along the Niukluk. Summer work in these benches will costly and should be abandoned in favor of winter work.

FOX RIVER.

On Fox River some mining had been in progress during the pa year, especially on I X L Gulch, a small tributary to Fox River 8 10 miles from Council. The rocks in the neighborhood are almo entirely schists and greenstones, but near Horton Creek there is massive limestone member which forms a prominent topograph feature. The contact between the limestones and schists was n examined in detail and it is not known whether it is mineralized not. The output from Fox River will be rather small, as the nu ber of workers is limited.

MYSTERY CREEK.

On Mystery Creek, a small tributary of the Niukluk from t north, a small amount of gold has been won, but the work was co ducted on a small scale.

BEAR CREEK.

The gravels which form the broad flat through which the Niukluk flows were prospected in the winter of 1905–6 on Bear Creek. Two shafts were sunk to a depth of about 50 feet, and fine sand, which was reported to be in many respects similar to beach sand, was found. The excitement attendant on the finding of old beaches in the Nome region has so stimulated the imagination of many of the prospectors that they see beach sand in all kinds of gravel. The so-called beach sand was not seen by the writer, and so no definite report can be made on the statement, which, if true, is of considerable importance in unraveling the complex history of the gold-bearing portions of Seward Peninsula. The scanty information at hand, however, leads to much doubt of the sea-beach origin of these sands. The reason for the doubt rests largely on the shape and size of the basin that would result if the whole region were depressed so as to bring the so-called beach down to sea level. Such a change would result in a narrow estuary, nowhere much over 4 miles in width, and in some places—as, for instance, 6 miles north of White Mountain—not over three-fourths of a mile. In such a body of water, wave and current action, the predominant activities in beach formation, would be very ineffective, and muds, silts, and river wash would be much more characteristic than clean beach sands. In this connection it is perhaps desirable to point out that the presence or absence of gold is in no measure dependent on sea beaches except under certain special conditions such as exist around Nome. The United States has a shore line composed of thousands of miles of beaches, and yet not 1 per cent of this entire length is auriferous in economic quantities. The idea, therefore, that old beaches and rich gold deposits are necessarily interchangeable terms should be discarded

MELSING CREEK.

On Melsing Creek, which was formerly one of the most productive streams in the district, not very much gold has been taken out during the last season. This was largely due to the extremely unfavorable weather conditions. It was so dry that only in the latter part of the season could enough water be obtained for mining purposes. When it did rain, so much water came down that it could not be handled by the miners, and consequently much of the rich ground was flooded. At the time of the writer's visit the only work in progress was near the junction of Basin and Melsing creeks. At this place the course of the pay streak, which lies only a few feet above the present stream level, is very sinuous and suggests that these gravels were laid down by a stream of relatively small size meandering widely on a flat slope. A feature of some interest was the occurrence of large granite and

quartzite bowlders, reaching 18 inches in diameter, in a layer of muck and decomposed vegetable matter lying above the gravels. The granite is but slightly decomposed and the bowlders are rather angular. These facts suggest a different transporting agent than running water. Associated with the auriferous gravels are in many places thin strata of cemented gravels in which the cementing material is mainly calcite. The cemented character prevents the separation of the gold in the sluice boxes, so that if much of this sort of gravel should be encountered recourse to some method of crushing would be necessary.

On Melsing Creek a method of preparing the sluice boxes which has not been seen in any other part of the peninsula was noted. This consisted of nailing a strip of canvas or cocoa matting on a plank slightly narrower than the bottom of the sluice box. On top of the canvas a strip of galvanized-iron screen, with about one-fourth inch mesh and the same width as the plank, was fastened. In use, this plank was placed in the bottom of the sluice box and the riffles laid on top, thus holding it in position. To clean, the plank was taken out of the sluice box, turned upside down, and pounded with a hammer or mallet. Although no comparative figures were available to prove the added efficiency of the sluice boxes thus equipped, the operator was completely satisfied with the results, as he was convinced that the additional saving of gold was very great. It is of course not necessary that every box in a set should be equipped with such a false bottom. Individual practice and study will determine the most effective number for different kinds of gold.

OPHIR CREEK.

Ophir Creek still continues to be the most productive of the tributaries of the Niukluk. The development of the placer claims along its course and on its main tributaries—such as Dutch, Crooked, and Sweetcake creeks—has constantly demanded additional water supply with greater head. To meet this demand high-level ditches have been constructed, but it was early recognized that even under the most favorable circumstances Ophir Creek could not be relied on to meet the growing demands. Consequently it has been necessary to lead water from other drainage areas into the Ophir Creek basin. The largest operation of this kind has been successfully carried out and undoubtedly permitted mining which the dry weather of last summer would have otherwise prohibited. This ditch takes water from Pargon River at Helen Creek, a small tributary about 2 miles north of the summit of Mount Chauik. The ditch is 11 miles long and in many places, where the slopes are excessive, flumes have been constructed. The water is led around the eastern flank of Mount Chauik and thence across the divide into the Ophir Creek basin. In order to obviate additional ditch construction, the water is discharged

into Ophir Creek and taken up again lower downstream by one of the existing ditches. It was estimated that about 8,000 miner's inches of water were available from the Pargon, but during the dry period of last summer only about 500 inches were delivered by the ditch.

Another project for leading water from Pargon River to Ophir Creek is under way, but as yet actual ditch construction has made little progress. Up to the present time the work of the company has been devoted mainly to surveying the course for the ditch, making preliminary observations, and acquiring rights of way. The proposed ditch will take water from a point considerably below the completed one, and for that reason should have more water available.

The operations on Ophir Creek during 1906 were carried on less by individuals and more by large companies than in previous years. The most active work had been done by the dredge at the "Portage," by elevators near Sweetcake and Dutch creeks, by derricks a little above Dutch Creek, and by shoveling in near the mouth of Crooked Creek. Above Crooked Creek no work has been done on Ophir Creek during the last summer. In regard to the tributaries it may be said that a little mining has been done on Sweetcake Creek, but the values do not seem to extend much more than a mile above its mouth. On Dutch Creek a little mining has also been done. The small stream joining Ophir Creek near claim "19 above" has been prospected, but does not seem to carry values above its mouth. Along Crooked Creek for a distance of 2 miles the creek has been worked continuously all summer by parties ranging in size from 2 to 14 men. The fact that almost all the side streams carry gold has led to an enrichment of the main-stream gravels. Practically every one of the bonanzas of Ophir Creek has occurred in the main stream at the junction of a side stream. The recognition of this feature, which also prevails on many other streams, should be of some assistance in prospecting undeveloped regions.

RICHTER, CAMP, AND GOLDBOTTOM CREEKS.

Richter Creek, the first tributary of the Niukluk from the southwest above Ophir Creek, although the goal of one of the stampedes that took place a few years ago, seems now to be exhausted and its output is negligible. Camp Creek has been worked by prospectors during the last summer, but the locations have been made mainly on the gravels near the Niukluk. The mine described on page 148 may be cited as an example of this kind of development. Goldbottom Creek and its branch, Warm Creek, tributary to the Niukluk a little above Camp Creek, have produced some placer gold during the last summer. Activities, however, have not been pushed with as much vigor as in previous years, only two or three small parties having been working on these creeks.

ELKHORN CREEK.

Elkhorn Creek has also been a small producer during the last year. The operations have been carried on for a distance of about 2 miles along the stream, but the largest amount of work has been done near the mouth. The section exposed in pits at the junction of the Niukluk and Elkhorn Creek is as follows:

Section at junction of Niukluk River and Elkhorn Creek.

	Feet.
Vegetation	2
Clay and muck	4
Sands and gravels	4

The lowest member showed considerable cross bedding in the sands associated with the gravels, thus indicating the variable character of the water by which they were deposited. Numerous pieces of wood in a more or less decomposed condition were found in the gravels. The surface form and internal structure suggest that the deposit is an alluvial fan of Elkhorn Creek rather than the flood plain of Niukluk River. Work on this creek was abandoned before the last week of September and, owing to the absence of miners, no estimate of the production or tenor of the gravels could be obtained.

CASADEPAGA RIVER.

MOUTH TO BONANZA CREEK.

The general impression of the mining which had been done along the Casadepaga in 1906 was that the work had been carried on more by prospectors than by active settled companies. As a result of this method of work the production from the stream and its tributaries will probably be small. On the lower course of the river as far as Bonanza Creek no mining had been in progress. Near Bonanza Creek two camps had been established to work the low bench gravels of the Casadepaga. These camps, however, have employed only two to five men each, so that not much work has been accomplished. A little work had been done on Bonanza Creek, but it was not visited.

BONANZA CREEK TO PENELOPE CREEK.

From Bonanza Creek to Penelope Creek the river gravels have been extensively prospected during the summer by a drill with a crew of six men, with the aim of determining the character of the ground. No statement as to the results of this work can yet be made. One peculiar feature noted in drilling below the mouth of Penelope Creek was that on certain of the river bars gold occurs on the surface and not on bed rock. There is no false bed rock of clay at these places and the surface concentration is due to the washing away of the gravels

of the bars during periods of flood, the particles of gold previously contained in the gravels being left behind because of their greater weight. On Big Four Creek, a tributary of the Casadepaga from the south between Bonanza and Penelope creeks, only assessment work has been done during the last summer. On Birch Creek, which flows into the Big Four about 5 miles above the Casadepaga, two camps have been engaged in working creek gravels below Shea Creek.

At Dixon Creek, 2 miles above Big Four Creek on the Casadepaga, there has been some development work. The bed rock at this place is schist and limestone, the creek appearing to follow the contact more or less closely. As this contact is in many other places the locus of mineralization it would seem desirable to further investigate the gravels of this creek and of the Casadepaga near its junction.

PENELOPE CREEK TO MOONLIGHT CREEK.

Penelope Creek is now the terminus of the Council City and Solomon River Railroad and by this line is about 32 miles from Solomon. There have been two camps on this creek, one near the mouth and one about a mile above. The upper camp has been the most active during the last summer. Four men have been employed and the gravel has been handled with horse scrapers. A short ditch has been constructed at a low level, but, as in other parts of the peninsula, considerable difficulty has been experienced from lack of water.

On Goose Creek only two men have been mining during the last summer and according to local reports not much more than wages has been produced. Three-fourths of a mile above Goose Creek there is a broad bench of gravels trenched by the Casadepaga which shows good values. Mining on this flat, however, has been inactive, pending the completion of a ditch from Moonlight Creek. (See p. 154.)

No mining except assessment work was done in 1906 on Canyon Creek. On Banner Creek also work was practically at a standstill. It is reported that all the gravels on the latter creek have been turned over and that the only values left are those that have been lost by the primitive methods in vogue when the creek was first worked. Certain claims are, however, held by annual assessment work, but the yield is seldom more than wages.

Willow Creek, which is noted on some of the Survey maps as Left Fork, is locally known as Lower Willow in order to distinguish it from Upper Willow Creek, also a tributary of the Casadepaga. Upper Willow Creek enters the river from the south about a mile west of Johnson Creek, while Lower Willow Creek has its mouth nearly opposite Ruby Creek. At the mouth of Lower Willow Creek two men have been working all summer. A mile above the mouth two men have been at work, but have been much hampered by the

lack of water. A mile above the forks of Wilson and Lower Willow creeks two men have been doing some work, but operations were suspended late in the season to allow the installation of a California grizzly. About 1½ miles above the fork of Wilson and Lower Willow creeks two men had been employed all summer. They stated, however, that the claim had been previously worked out, and their operations this summer consisted merely in saving some of the values that had been lost in the earlier mining. A short ditch at a low level takes water from the upper part of the creek and carries it to the discovery claims, a distance of about 2 miles. The geology of the region at the forks of Willow Creek is complex, the bed rock consisting of limestone and both chloritic and graphitic schist. The gold of this part of the stream has probably been derived from a near-by source. Mineralization is evident in at least two places at the schist and limestone contacts on the south side of Lower Willow Creek. At one place sulphides were recognized in a quartz vein, and numerous copper stains on weathered vein stuff were found on the summit of the divide between Lower Willow Creek and the Casadepaga near the head of Ptarmigan Creek.

On Ruby Creek two parties have been at work during the last summer, but the creek is now exhausted. It is said that the values have been more completely extracted from the gravels of this creek than from those of any other stream in the Casadepaga drainage, so that reworking these gravels in the future will not be remunerative.

On Moonlight Creek the main activity during the last two years has been ditch building. This creek heads in a series of bare limestone hills with steep slopes, so that the run-off is high. The ditch has an intake at an elevation of about 500 feet. It is proposed to carry the ditch across Canyon Creek to the broad bench of Casadepaga River about three-fourths of a mile southwest of Goose Creek. The water supply from Moonlight Creek will be augmented by a ditch line from Upper Willow Creek with its intake at such a level that it delivers water to the ditch at Moonlight Creek at an elevation of 500 feet. It is estimated that the ditch will have an average delivery of 1,500 to 2,000 inches of water.

An eighth of a mile below the junction of Moonlight Creek and the Casadepaga there has been some slight exploration of the bench gravels that occur a few feet above the level of the river. The gravels seem to be typical river gravels, but the floor on which they rest is rather uneven. Old channels have been reported in this district, but the rumors could not be investigated. Above Moonlight Creek there have been no mining operations on the Casadepaga during the last season.

AURIFEROUS LODE DISCOVERIES.

During the last few years there has been a noticeable increase in activity in the search for lode mines, with the result that several veins of promising character at the outcrop have been located. As has already been stated, the Big Hurrah mine is the only gold-bearing lode mine in operation in the district at the present time, but this condition can hardly prevail long.

DESCRIPTION OF LOCALITIES.

A very promising ledge of quartz has been located on the divide between Goldbottom and Ophir creeks near the head of Crooked Creek. The lode occurs near the contact of limestone and schist, and specimens show considerable free gold. It is reported to run nearly $40 to the ton, but it is not known how the sample was collected. This discovery seems to be very significant in connection with the fact that the gold in many parts of Crooked Creek is very sharp and angular and much of it has quartz fragments attached. A specimen of gold seen near the mouth of Crooked Creek, derived from a placer deposit at that place, was of such fragile shape and crystalline form that it seemed impossible for it to have been carried more than a few feet from the vein from which it was derived.

Another lode which has recently been found is located about half a mile southeast of Post Creek, a tributary of the Niukluk from the north. This vein has quartz as the gangue mineral, occurs at the contact of a schist and limestone, and is about 8 feet in width. According to reports it shows considerable free gold, and the values obtained by crushing and panning indicate that the vein would run nearly $35 to the ton. No responsibility is assumed for this statement, as it is not known how the sample was collected. It is an interesting speculation whether or not the vein on the divide at the head of Crooked Creek and this vein near Post Creek are connected.

Still another lode has been located on the south side of the Niukluk near the head of Camp Creek. No specimens were seen from this vein, and the descriptions were meager. They sufficed, however, to make it certain that a quartz vein carrying free gold in visible quantities has been found at this place and that developments are being pushed as efficiently as a small force and funds permit.

In addition to these well-authenticated finds, there are numerous rumors of other lode locations. These reports seem to indicate clearly that more and more attention is being paid to the search for lode deposits throughout the district.

ASSOCIATION OF LODES AND CONTACTS.

In view of the fact that all the lodes so far discovered are in close proximity to the limestone-schist contacts, it may be interesting to point out that Brooks, Collier, and Hess, in a manuscript which has not yet appeared in print, have suggested that these contacts may be zones of weakness along which ore-bearing solutions could most easily penetrate. If this suggestion is verified by subsequent closer inspection of a large number of examples, it will be of immense importance in directing the prospector to the more likely places of mineralization. It must be remembered, however, that in making so broad a generalization it is not intended to assert that in every place where a contact is found a deposit of economic importance will occur. The statement simply means that a valuable ore deposit is more likely to occur at such a place than at any other. If, however, the shattered and easily pervious condition which is so commonly associated with these contacts is duplicated elsewhere, ore deposits are just as likely to occur in those places as in the contact zone.

SILVER-LEAD ORE.

On Omalik Creek, a branch of Fish River, which is a tributary of the Niukluk, a silver-bearing galena lode has long been known. This vein was the first lode discovered in Seward Peninsula, and its discovery dates back to 1881. Since that time it has been worked more or less intermittently without producing much metal. During the last summer renewed attempts were made to reopen the vein. The mine was not visited by any member of the Geological Survey, but from the current reports it seemed to be the intention of the company to spend the summer months in taking in supplies, but active mining operations were not to be commenced until the freeze-up occurred. The high cost of supplies and labor makes this undertaking one of great expense.

GEOLOGY AND MINERAL RESOURCES OF IRON CREEK.

By Philip S. Smith.

INTRODUCTION.

Iron Creek, one of the largest tributaries of the Kruzgamepa, joins that river near the great bend about 11 miles east of Salmon Lake. Although really continuous, Iron Creek bears three names in different parts of its valley; thus from its mouth to Left Fork, a distance of 7 miles, the stream is called Iron Creek; above Left Fork as far as Eldorado Creek, a distance of 1 mile, it is called Dome Creek, and from Eldorado Creek to the divide it is called Telegram Creek. This confusion of names is due to the interpretation of the mining laws which permits the staking of additional claims on different creeks—i. e., creeks having different names. There are four main tributaries, the three largest being from the south and the fourth and smallest from the north.

Owing to the fact that some errors occur in the reconnaissance map of 1900,[a] the only map prepared by the Geological Survey of this region, it has seemed advisable to correct such inaccuracies as were noted in a hasty trip along the stream in 1906. Much assistance in platting the district was afforded by the transit notes of a ditch survey made by J. M. Love, of the Gold Beach Development Company. A corrected map of the Iron Creek basin is shown in fig. 8. It will be noted that this basin is roughly triangular. The western side of the triangle forms the divide between the drainage of the Kruzgamepa and that of Iron Creek. The southern side of the triangle in the western part separates the Iron Creek drainage from the headwaters of Gassman and Venetia creeks, both tributaries of Eldorado River. The divide from Venetia Creek is low, being only about 800 feet above the mouth of Iron Creek, or 1,000 feet above the sea, so that it affords a good route for a road to Nome. The eastern portion of the southern side of the triangle forms the divide between the Iron Creek and Casadepaga drainages. A low pass, with an elevation of about 1,000 feet, permits a good wagon road to run up Telegram Creek and down Lower Willow Creek to the Council City and Solomon River Railroad, a distance from the junction of Iron and Canyon creeks of 13 miles.

[a] Reconnaissances in Cape Nome and Norton Bay regions, Alaska, in 1900; a special publication of the U. S. Geol. Survey, 1901, pl. 17.

Now, however, that the Seward Peninsula Railway from Nome to the Kougarok has been completed beyond the mouth of Iron Creek, it is probable that with reasonable freight rates the use of the wagon roads will decrease, though freight is now delivered at Iron Creek by winter hauling from Nome for only 2 cents a pound. The northern side of the Iron Creek drainage basin forms the divide from Sherret Creek and several smaller streams which flow northward into the Kruzgamepa.

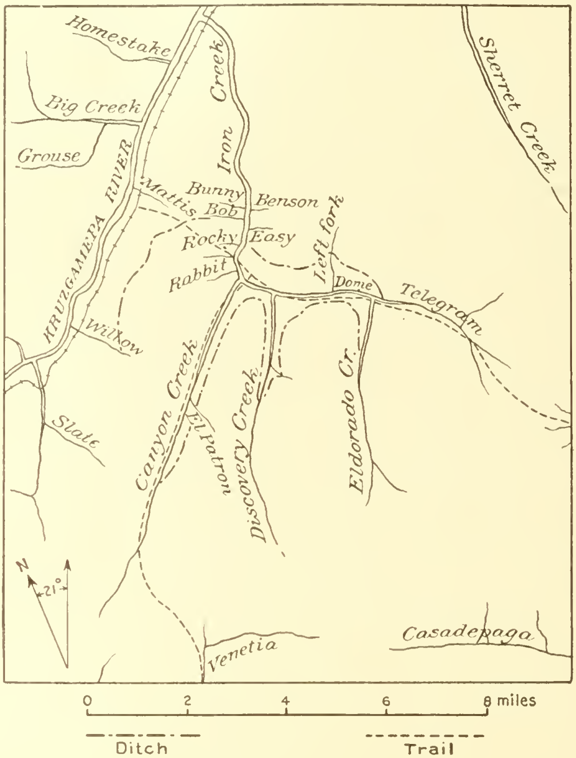


FIG. 8.—Sketch map of Iron Creek basin.

PHYSIOGRAPHY.

STAGES OF VALLEY CUTTING.

The physical features of the district are complex, and only the more striking facts can be presented here. An older topography, in which the present stream is intrenched, is preserved in the upper slopes of the valley walls. In this portion the bed rock is so covered over that exposures are practically wanting. This is due to a period of erosion and the accumulation of a heavy mantle of waste that reaches nearly to the top of the divide. The higher portions of the divides are generally bare, consisting of fantastically curved pinnacles of rock from

which taluses with steep slopes, practically uncovered by vegetation, descend, gradually merging with the smoother moss-covered slopes of the middle portion of the valley walls.

The streams in their lower courses flow in rock-walled canyons. In tracing any one of the streams headward the canyon is found to decrease in height and to merge gradually with the older topography previously mentioned. The history of these features suggests that the former topography of gentle slopes and wide, open valleys was produced by the long-continued erosion of rivers and weathering. Subsequently uplift of the region renewed the down-cutting power of the streams, so that canyons were carved in the floors of the old valleys. This erosion allowed rapid reassortment of the old gravels and waste and thus effected the concentration of any gold or other heavy minerals which may have been contained in the gravels.

The canyon cutting ceased, however, before it had progressed beyond the lower portions of the streams. The interruption was produced either by a movement of the land or, as is more probably the case, by a climatic change which decreased the amount of water transported by the streams. Such a change may have also been responsible for the disappearance of the local glaciers which were formerly present in the Kigluaik Mountains. Whether the climatic change had anything to do with the retreat of the glaciers or not is, however, of slight importance in this discussion. Some change must have occurred, for the streams are no longer down-cutting but actually building up the floors of their valleys. The reason for believing that the change must have been one which affected the rainfall rather than the elevation of the district with respect to sea level is based on the shape of the rock canyon. The canyon has a broad, swinging course which is so symmetrical that it could not have been produced by the straggling present stream, which occupies only a small portion of the floor between the rock walls. Many other streams in different parts of Seward Peninsula show this same feature. The extensive development of this phenomenon suggests a widespread cause, such as climatic change, rather than a local cause, such as uplift.

EVIDENCES OF GLACIATION.

Another feature of some theoretical interest is the presence of granite bowlders on the divide near the low sag at the head of Mattis Creek. In the rapid reconnaissance it was impossible to examine the district with sufficient care to make a final statement as to the origin of these bowlders. It is known, however, that there is no granite of similar character south of the Kigluaik Mountains. Furthermore, the granite bowlders are unweathered, showing that they have not been in their present position a very long time geologically. Although the question has not been carefully studied in the field, it is suggested that possibly

these bowlders have been brought by glaciers from Kigluaik Mountains and carried into their present position by ice blocks floating on a lake formed by glacial obstruction of the drainage. This suggestion is to be regarded only as a working hypothesis, but it fits in with the known facts, which may be summarized as follows: The angular, unweathered form and foreign character of the granite and the presence of shore lines at considerable elevations. Lakes of this type are common in regions that are at present glaciated, and evidences of such lakes have been recognized in many places where glaciers have now disappeared.

GENERAL GEOLOGY.

The bed rock of the district belongs to the Nome series. It consists of a series of much faulted and contorted limestones and schists and some greenstones. The greatest development of limestone occurs in the lower part of Iron Creek, but a great number of thinner beds interlaminated with schists are encountered even up to the headwaters. It is believed that the numerous alternations of schist and limestone are indicative of the source of the Iron Creek gold. Although no extensive proof of mineralization at the limestone-schist contacts has been found in this locality, the fact that such contacts are the loci of mineralization has been very well established in other parts of Seward Peninsula.

The rocks of the Iron Creek district trend northeast and southwest and dip toward the southeast, but there are numerous exceptions to this general direction, as the rocks are complexly folded and faulted. The deformation and consequent shattering that the rocks have undergone has undoubtedly resulted in the formation of zones of pervious rock in which mineralization has taken place. The streams also have taken advantage of the northeast-southwest structure and practically all the tributaries are arranged parallel to this direction.

In lithologic character the rocks are similar to the Nome series as described for other parts of the field. The schists present two main lithologic facies, namely, graphitic and chloritic. No boundary between the two can be drawn at the present time, although it is believed that detailed study would solve their interrelation and structure. The chloritic schists are most extensively developed in Iron Creek below Telegram Creek. They are thinly laminated, with wavy cleavage, and rusty brown to greenish gray in color. Chlorite and quartz are the only minerals distinguishable in the hand specimen. Graphitic schists are most abundant on Telegram Creek above Eldorado Creek. These rocks are in general but slightly schistose and would better be described as dark, nearly black, graphitic quartzites, with here and there schistose phases. Hand specimens show considerable quartz and a little chlorite. The other constituents are not distinguishable by the eye, though the presence of graphite is recognized

by its soiling the hands. Here and there some sulphides are found, especially in the places where dislocations occur.

The greenstones which occur in the Iron Creek region have not been studied in detail, but seem to be similar to those found in the adjacent country nearer Nome. If this correlation is correct, they are mainly of intrusive origin. Rumors were heard of an extrusive flow of greenstone south of Iron Creek, but neither was it found in place nor was any float of an extrusive greenstone seen, so that doubt is felt about the occurrence of a surface flow.

MINING DEVELOPMENTS.

GENERAL CONDITIONS.

Mining on Iron Creek has been much retarded by the inaccessibility of the region, but this obstacle is now disappearing with the building of railroads and wagon roads. Freight from Nome can now be delivered by the Seward Peninsula Railway at the mouth of Iron Creek, but the schedule of rates was not learned. It has already been noted that in winter supplies can be brought in by team at a cost of 2 cents a pound. The cost of summer hauling by team to Iron Creek is now, owing to the good condition of the road to Nome, but little higher than the winter rate.

DITCH CONSTRUCTION.

In 1906 work on Iron Creek and its tributaries had almost ceased at the time of the writer's visit in the latter part of September. With one exception the work for the season seemed to have been carried on by small outfits of only one to five men each, and a liberal estimate of the output of the creek and tributaries for the year would not exceed $50,000. The most important work during the last season has been ditch construction, about 13 miles having been built. One ditch taps Eldorado Creek at a point 1 mile above its junction with Telegraph Creek and leads the water along the south wall of Iron Creek to a penstock near the junction of Discovery and Iron creeks. A second ditch takes water from Canyon Creek 5 miles above its mouth and leads it along the east wall of Iron Creek, thence following the south slope of the valley to the west side of Discovery Creek, along which it runs southward to a point 2 miles above the mouth of the stream, where it crosses and extends along the east side of the valley to the penstock previously noted. Another ditch on the north side of Iron Creek, which takes its water from the junction of Telegram and Eldorado creeks, is also being constructed by the same company. Between sixty and seventy men at a time have been employed in the construction of these ditches. They were not completed until the latter part of September, so that water for washing the gravels was available for

only about two weeks. The ground operated at present by the company is on Iron Creek at the mouth of Discovery Creek. A hydraulic elevator has been installed to handle the flood-plain gravels, and active mining operations will be conducted during the coming year.

MINING ON MAIN STREAM.

Between Discovery Creek and Left Fork on Iron Creek there is a fractional claim which has been worked for the last two years on a small scale. From one to five men have been employed on this claim all summer. The gold is coarse and easily saved. Both rusty and bright gold are found. The values occur in a thin pay streak on limestone and in the cracks and crevices of this bed rock. The small amount of ground in this claim has prevented any large-scale developments.

At the junction of Left Fork and Iron Creek three men have been continuously employed all summer working creek gravels. The method of working these gravels has been by means of a bed-rock drain and sluice boxes. Several nuggets worth $30 or $40 each have been found in this place. The bed rock is a much shattered limestone with thin bands of chloritic schist both above and below it.

A short distance upstream from Left Fork the largest nugget recorded from Iron Creek was found. This nugget weighed over 30 ounces and was valued at $600 on the assumption that the gold was worth $18.50 an ounce. It is a fact of some significance that upstream from this point, which is about half a mile above Left Fork, the gold is all rusty, whereas below both rusty and bright gold occur. The reason for the absence of bright gold above is believed to be that this point marks the place where the older and newer valleys merge. In other words, upstream the creek flows in the nearly unmodified old valley, while downstream it has cut below that level. The result of the down cutting has been to wear some of the gold and expose fresh, shiny surfaces; whereas the gold that has been practically unmoved has a rusty coating.

Between Left Fork and Eldorado Creek only one camp was in operation in 1906. Five or six men have been at work at this place, but as it is understood that this portion of the creek has already been worked over three times it is doubtful whether subsequent work will be remunerative. The gravels are apparently similar to those already noted.

Above Eldorado Creek the main stream, as has been previously stated, is called Telegram Creek. One man only has been at work on this stream during the last year. This claim is located at a point about a mile from the divide. The bed rock is mostly graphitic schist with some thin limestone and schist bands. Several nuggets, worth as much as $100 apiece, have been found on this claim, and it is reported that very coarse gold is found even on the crest of the divide from Willow Creek. The water supply of Telegram Creek is small,

specially in a dry year, such as 1906. Often this lack has hindered r in large measure prevented exploration of the gold gravels that have een found by prospectors in this part of the Iron Creek basin.

MINING ON TRIBUTARIES.

On the tributaries of Iron Creek but little work has been done. Bunny Creek, the fifth stream which enters from the west below Canyon Creek, is not over three-fourths of a mile in length. Two nen have done a little work on this stream last summer, but it probbly produced not more that $100 or $200. On Bobs Creek, the ext small stream south of Bunny Creek, the only work done during he last season has been on the upper part. This claim has been vorked with water brought over the divide from Willow Creek, the rst tributary of the Kruzgamepa east of Rock and Slate creeks. Considerable trouble has been experienced with the ditch, as a large art of it is built on frozen ground, which melts under the water. This ditch carries only about 400 miner's inches of water. Even this mall amount is more than is yielded throughout the season by Willow Creek, and it is proposed to extend the ditch next year 3 or 4 miles to Slate Creek.

Easy Creek, which enters Iron Creek from the east opposite Bobs Creek, has shown good values in the lower portion. Three men were t work at this place last summer, but it closed down rather early in he season owing to the drought. Little more than assessment work as been done on the other claims along Easy Creek. The next small tream to the south is Lulu or Benson Creek. Four men have been perating on this creek the entire summer. On Rapid, Rocky, and Rabbit creeks, the three other small tributaries of Iron Creek from he west below Canyon Creek, little more than assessment work has een done during the last season, although they are completely staked.

Except on Canyon Creek, no work has been done on any of the arger tributaries of Iron Creek. On a little tributary of Canyon Creek called El Patron Creek, about 3 miles above the junction with ron Creek, one man has been at work all summer. However, but ery little gold has been produced owing to the lack of water. It is xpected that with the completion of the Canyon Creek ditch water nay be purchased, so that work will be pushed with greater activity n the coming summer.

SUMMARY.

In summarizing the Iron Creek region it may be said that the gold s mostly coarse and easily saved; that it has been derived from a elatively local source; that water for the economic development of he placers is at hand, and that the questions of freighting and transortation are rapidly being effectively and satisfactorily settled.

THE KOUGAROK REGION.

By Alfred H. Brooks.

INTRODUCTION.

"Kougarok district" is the name[a] generally given to an auriferous gravel region lying in the central part of Seward Peninsula and drained, for the most part, by Kougarok River. This paper will describe, besides the drainage basin of the Kougarok, the other gold-bearing streams tributary to Kuzitrin River. Investigations were begun in this field in 1900 by the writer,[b] assisted by A. J. Collier, soon after the first actual discovery of workable placers, and were extended by Mr. Collier[c] in the following year. In 1903 the district was reexamined by Messrs. Collier and Hess, who prepared a statement for a report not yet in print.[d] The writer was again in this field in 1906, spending about ten days in visiting some of the more important localities. The notes of Messrs. Collier and Hess have been freely drawn upon, but for the conclusions here advanced the writer is alone responsible. All of the surveys thus far made have been preliminary, and the data obtained leave much to be desired, both as to the details of the geology and the distribution of the placer gold.

TOPOGRAPHY.

The northwestern front of the Bendeleben Mountains slopes off to a lowland basin, 20 miles long and 10 miles wide. On the southwest the basin walls gradually approach each other and finally constrict the valley to a width of about 3 miles, but 10 miles below it opens out again to the low ground encircling the east end of Imuruk Basin or Salt Lake, as it is popularly called. The north wall of the lowland basin slopes up gently to an upland, whose flat summits stand at altitudes of 800 to 1,600 feet. Here broad, flat-topped interstream areas, diversified by some higher domes reaching altitudes of 2,500 feet, are separated by wide valleys. As elsewhere in the peninsula the upland summits mark a former stage of erosion. After the entire

[a] The "Kougarok precinct" includes the entire drainage basin of Kuzitrin and Kruzgamepa rivers.

[b] Brooks, A. H., assisted by G. B. Richardson and A. J. Collier: A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula (in Reconnaissances in the Cape Nome and Norton Bay region, Alaska, in 1900, a special publication of the U. S. Geol. Survey, 1901).

[c] Collier, A. J., A reconnaissance of the northwestern portion of Seward Peninsula: Prof. Paper U. S. Geol. Survey No. 2, 1902.

[d] Collier, A. J., Hess, F. L., and Brooks, A. H., The gold placers of a part of Seward Peninsula (in preparation).

egion was planated, uplift formed a plateau, which is deeply disected by the present watercourses.

Kuzitrin River carries the drainage of the district southwestward to muruk Basin, a tidal inlet connected with the sea at Port Clarence.

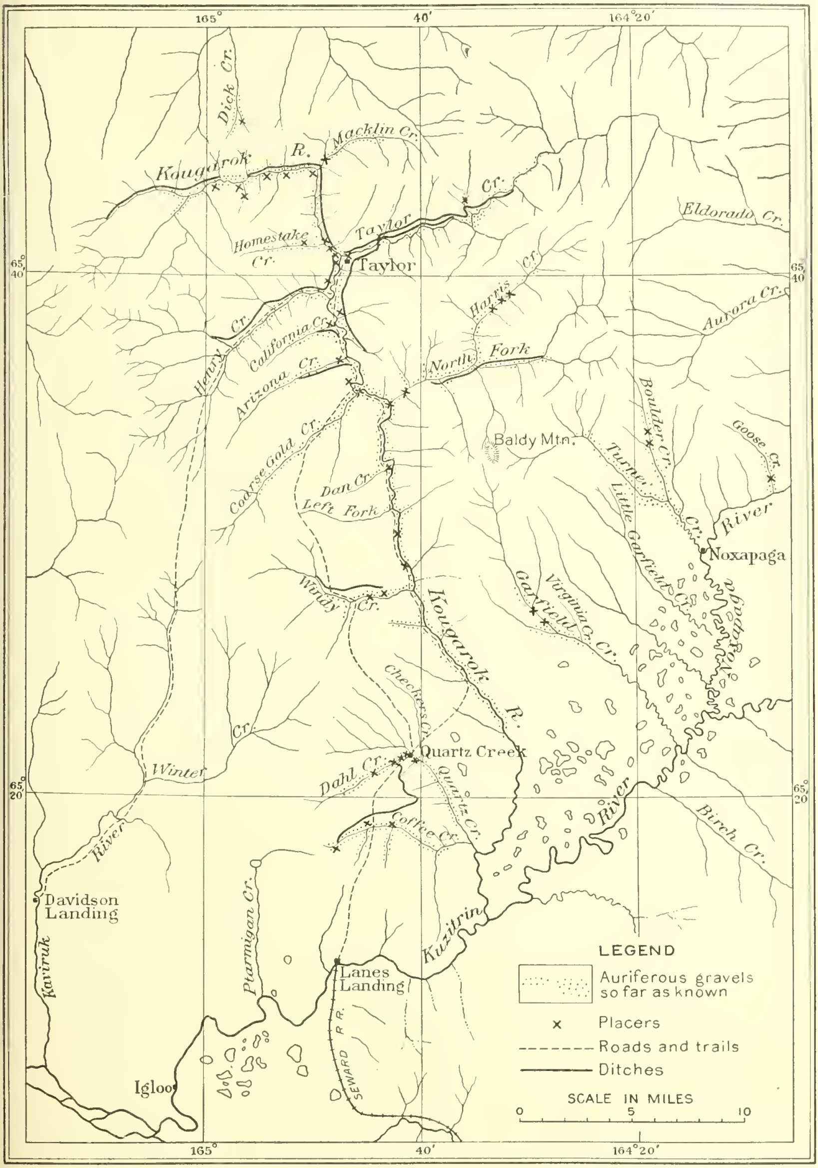


FIG. 9.—Sketch map of Kougarok region.

This river meanders with sluggish current across the lowland basin already described, receiving numerous large tributaries from the

north, the longest being Noxapaga and Kougarok rivers and Garfield Creek. (See fig. 9.) A number of smaller streams heading in the Bendeleben Mountains are confluent from the south, but these are outside of the province here discussed. The northern tributaries find their sources in the upland region, through which they meander in valleys which have tortuous courses and whose walls are in many places broken by well-defined benches, many of them covered with gravel. Though the topographic features described show no great variety in character of the relief, there is abundant evidence that the physiographic history of the region was far more complex than this simple analysis would indicate. There were no doubt at least two and probably more epochs of planation. Moreover, the benches along the valley walls bear evidence that the uplift which brought about the incision of the present valleys was intermittent.

As elsewhere in the peninsula, the dominant vegetation is moss. Timber is entirely absent, but thick growths of alder and willow are found along the watercourses. Grass, though not abundant, occurs in favored localities along the valley floors. The hill slopes are usually moss covered, with here and there some grass. Only on the highest summits and in sharply cut valleys is bed rock exposed, a feature of the region which makes it exceedingly difficult to decipher its geology.

GEOLOGY.

The stratigraphic units described in the reports referred to—the Kigluaik and the Nome series, including a subordinate member of the latter, known as the Port Clarence limestone—are represented in the Kougarok region. The limestone, schists, and granites of the Kigluaik series go to make up the Bendeleben Mountains, which stretch along the southern margin of the field here described. So far as known, these rocks have not been found to be gold bearing and need no further mention here.

This older series is separated by a broad belt of alluvium, flooring the Kuzitrin Valley, from the schists and limestones of the Nome series, which form the country rock of the uplands and are also the source of the placer gold. Here the Nome series is clearly divisible into two groups—(1) limestone and (2) a succession of graphitic phyllites and mica and greenstone schists, with some beds of semicrystalline limestone. The schist series is closely folded and faulted, and its stratigraphic relation to the massive limestone has not been definitely established. Collier's interpretation of the known facts leads him to the opinion that the limestone is the younger formation, while, on the other hand, the writer is inclined to the belief that the schists overlie the limestone. The latter view finds support in the

fact that Moffit,[a] in the adjacent region to the northeast, found a schist series resting on a massive limestone formation.

Be the stratigraphic relations what they may, the fact of the occurrence of two series, one essentially schistose and the other a massive limestone, is well established. The limestone occurs in one area with oval outline lying between Kougarok and Noxapaga rivers, and in another of more irregular contour between Kougarok and American rivers. Between these two limestone belts lie the schists, which here exhibit great irregularity of dip, being closely folded and faulted.

Besides the sediments above described, several types of igneous rocks occur in this region or immediately adjacent to it. Greenstone schists, which are probably altered intrusives, occur with the schistose rocks. Dioritic rocks, some of them massive, others more or less schistose, are not uncommon among the schists as dikes and small stocks. A large stock of granite occurs a few miles northeast of the Kougarok-Arctic divide. There is a noteworthy hot spring near the margin of this granite mass. In the upper Kuzitrin Valley a large area is occupied by a basalt lava stream of recent age.

As in the other placer districts of the peninsula, the schistose rocks appear to be the source of the placer gold. Quartz seams and small veins are common in the schists and many of them are iron stained. Reports from prospectors indicate that some of these veins carry gold, but, so far as known to the writer, no lodes of commercial value have yet been found. It is said that a copper-bearing lode has been found in this district.

There appears to have been two generations of quartz intrusives. The earlier of these was injected previous to the extensive deformation of the schists, for its veins are crushed and sheared. The later intrusion, which cuts the first system of veins and is comparatively little deformed, appears to be more commonly mineralized than the first. The presence of the recent granite intrusion at a near-by locality suggests a genetic relation between the second generation of quartz and the granite, but of this there is no proof.

This district lends additional support to the view elsewhere set forth (pp. 25, 130–132), that the locus of mineralization lies at or near the contact between the schists and the limestones. There appears to be a close correspondence between the limestone and schist contacts and the distribution of the placer gold, so far as determined.

The alluvial deposits fall into three groups—(1) stream and river gravels; (2) the gravels, sands, and clays which floor the basin lowlands; and (3) bench sands and gravels. Glaciation has taken place in the Bendeleben Mountains, but there is no evidence that these ice masses ever crossed the Kuzitrin Valley to the upland on the north.

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[a] Moffit, F. H., The Fairhaven gold placers: Bull. U. S. Geol. Survey No. 247, 1905.

It is quite possible, however, that the basin of the Kuzitrin may have been in part covered by glacial ice at one time.

The stream and river gravels, which constitute the best-known type, vary in character according to their place of occurrence. The developed placers are nearly all in the stream and river gravels. So far as known they carry, as a rule, only material derived from the basins in which they are found. Much of the material is well rounded, but that of the pay streaks in the placers is in many places subangular. Quartz usually dominates as a constituent of the pebbles. In some streams, such as Kuzitrin River, the gravel bars are made up of iron-stained quartz, almost to the exclusion of all other material. Sands and some clay occur interbedded with the stream gravels, forming, however, but a small percentage of the bulk of the alluvium. In all the smaller streams and in parts of the larger ones a bed of clay or sandy clay, in which more or less vegetable matter is intermingled, forms the topmost layer. This surface bed, which varies in thickness from 2 to 30 feet and is called by the miners "tundra," appears to be a subaerial accumulation, due in part to the decay of vegetable matter and in part to the deposition of silts during the rainy season. Though sometimes explained as a lake deposit by the miners, its distribution and character seem to preclude lacustrine origin.

The gravels, sands, and clays of the basin lowlands, forming the second type of alluvium, are known only where exposed by river erosion. At such places they consist of material identical in every way with that of the first group except that the material is somewhat finer. Some fragmentary evidence furnished by drill records goes to indicate that much of the basin is filled by clay deposits whose genesis can probably be best explained by lacustrine action. The determination of the outline of this old lake and of the cause of its formation must await further investigation. It is worthy of mention, however, that the surface deposits of gravel and sand in the Kuzitrin basin probably as a rule do not exceed 20 or 30 feet in depth. This, however, applies only to the basin, for in the constricted part of the valley the gravel deposits probably have a much greater depth.

Bench gravels are of common occurrence in the district. The best known are those along the main Kougarok between Taylor and Windy creeks, and these have proved to be auriferous. Similar deposits occur on the upper Kougarok, but have been little prospected. These bench gravels are of the same character as the alluvium of the present streams. The sands and gravels which form the extensive bench at the mouth of Quartz Creek and continuing up that stream to Dahl Creek are described on page 173.

Another type of surficial deposit that deserves mention is the ground ice, which here occurs more extensively than in the Nome region. Along the southern slopes of the valleys it forms in many places almost

continuous beds for several miles. It varies in consistency from a frozen mud to almost pure ice. Fragments of beaver-gnawed wood have been found in this ice at a number of places. The ice beds usually slope with the valley wall, and some of them extend up the hillside to a height of 100 feet above the stream. This ice can probably best be explained by the accumulation and subsequent solidification of winter snow, which has become buried by the talus and alluvium. The thick coat of moss, once established, effectually prevents the thawing of the ice. Ground ice is a perpetual source of trouble and expense to the ditch builders.

DEVELOPMENT.

This district was probably visited by prospectors as early as the summer of 1899, though claims were first staked during the winter of 1899–1900, and it is unlikely that any actual discovery of gold was made until the following summer. A rush from Nome to the new field took place in March, 1900, and another in July of the same year. Harris Creek appears to have been the scene of the first claim staking in March, and in July gold was found on Quartz and Garfield creeks. In August and September considerable gold was taken out of the shallow placers of these two creeks. In the meantime gold had been found on the main Kougarok and many of its tributaries, but no claims were opened up. In 1901 there was a decrease in the gold output, for the shallow diggings were rapidly exhausted and no very rich gold had been found on other creeks. The remoteness of this field from transportation discouraged prospectors except those with good financial backing. There were no bonanzas to give an impetus to mining. Probably the most important discoveries were those of Kougarok River, but these could be exploited by the individual miners only during low stages of the water, and sudden freshets often destroyed the work of weeks of preparation. Thus the mining interests in the Kougarok district may be said to have lain dormant for several years, though some gold was produced every year, chiefly on Dahl Creek. With the successful construction of ditches at Nome came a renewed interest in this outlying placer field. In 1903 T. T. Lane constructed a ditch from the head of Coffee Creek to a bench at the mouth of Dahl Creek, and this was the first long ditch in the district. In the following years many more ditches were planned and surveyed. In 1905 and 1906 ditch construction went on with feverish activity, and by the end of last summer upward of a hundred miles of ditch were planned, about half being completed. The larger ditches can be enumerated as follows:

The North Star ditch extends from Arctic Creek, on the east side of the Kougarok, to the mouth of Taylor Creek and up that stream about 10 miles, with a total length of 15.2 miles. The Cascade ditch takes

water from Taylor Creek, about 6 miles up, and discharges at t mouth of the creek. Both these ditches were completed in 190 The Kougarok Mining and Ditch Company had one ditch in operati in 1906 and two more partly constructed. Of these the Homestal ditch, which heads on the Kougarok 3½ miles above Macklin Cree and discharges at the mouth of Homestake Creek, with a head of 1 feet, was completed in 1905. Work has been begun on the Altoo ditch, which heads 1¼ miles above the mouth of Washington Cree A third ditch has been located, to be built up Macklin Creek, takir water from Schlitz and Reindeer creeks north of the Arctic divid T. T. Lane has completed a ditch from Henry Creek, discharging a Homestake Creek. All the above-mentioned ditches discharge withi a few miles of one another on Kougarok River and represent an aggre gate outlay that hardly seems warranted by the developments i placer mining.

The Irving Mining Company has constructed a ditch from Washing ton Creek along the north slope of the Kougarok Valley nearly to th mouth of Mascot Creek. Another ditch that has been built on Nort Fork by the Northwestern Mining Company heads at the junction o Alder and French creeks and is to be built to the Kougarok, abou 7 miles being completed in 1906. The Lane ditch, from Coffee Creel to the mouth of Dahl Creek, has already been mentioned. Smalle ditches have been built or surveyed at various places, includin Arizona, California, Coarse Gold, and Windy creeks. Besides these there are many other schemes for ditch building which have not gon far enough to deserve individual mention.

The summer of 1906, being abnormally dry, was especially favorabl for ditch construction, but worked havoc with those who were pre pared to sluice. It is perhaps well, however, that the managers of th large companies should know what they may expect and be able t include an allowance for a dry season in their estimate of cost. Th records show that in the last seven years there have been two notabl dry summers (1900 and 1906) and that therefore the last season is no by any means as abnormal as some promoters would try to make th public believe.

Up to 1906 the Kougarok district could be reached from Nome only by an overland journey of about 100 miles or by a very circuitous water route via Teller, Imuruk Basin, and Kuzitrin River. From Lanes Landing, at the head of scow navigation on the Kuzitrin freighting by wagon to the creeks cost from 6 to 15 cents a pound, the winter rates being much lower. J. M. Davidson and Andrew J. Stone who are among the largest operators in the district, have established a transshipping point on Kaviruk River,[a] called Davidson Landing and built a road from this place to the upper Kougarok region, a distance of 40 miles. Small lighters can be towed directly from the

[a] Called locally Marys River.

ship's side at Port Clarence to Davidson Landing, so that at least one handling of freight is avoided.

In 1906 the Seward Peninsula Railway was extended northward to the head of Nome River and then down the Kruzgamepa to Lanes Landing. Surveys have been made looking to a further extension of this line up the Kougarok Valley. This railway will bring the district into close touch with Nome and will do much to accelerate its development. The recording office now at Igloo, 7 miles below Lanes Landing, will in all probability be moved to a more accessible point on the railway.

Mining operations in 1906 may be summarized as follows: One hydraulic plant was operated for a part of the season on a bench claim on Dahl Creek and two on the main Kougarok River above the mouth of Taylor Creek. The two latter utilized the plant to remove the overburden and part of the pay streak, bed rock being cleaned by hand. In both cases hydraulic lifts were operated. Considerable work was done on the lower four claims on Dahl Creek by shoveling into sluice boxes. Ground sluicing was done by a number of operators, notably on Windy Creek and on Solomon Creek, a tributary of Taylor Creek. Several claims were worked in a small way on Coffee Creek and on some of the tributaries of the Kougarok.

A dozen outfits were engaged in mining the river gravels and some of the tributary gulches of the Kougarok above Macklin Creek, but were handicapped during the earlier part of the season by lack of water and later by excess of water, which flooded them out. Below Taylor Creek, on the main Kougarok, attempts were made to exploit the bench gravels either by sinking shafts and drifting or by the aid of small hydraulic plants, but in most places the equipment was insufficient to produce anything more than meager results. Probably the most successful of these operations was the drifting on some benches on the west side of the Kougarok near the mouth of Taylor Creek. Harris, Garfield, and other creeks received some attention. Chiefly owing to the inadequacy of the water supply it is unlikely that there were, all told, over 150 or 200 men engaged in productive mining in this region.

It is thought that the amount expended in ditches and purchase of claims during the last two years (1905–6) probably exceeds a million dollars. Such an expenditure hardly seems justified by the placer ground actually proved. The total gold output, including that of 1905, is estimated at $585,000, distributed probably about as follows:

Gold production of Kougarok district, 1900–1905.

1900	$50,000	1904	$150,000
1901	35,000	1905	200,000
1902	50,000		
1903	100,000		585,000

This amount is, however, only an approximation. It should be noted that this does not include the output of the entire Kougarok precinct, but only that part of the precinct which is described in this paper. The production of 1906[a] was very small, owing to the lack of water.

DISTRIBUTION OF AURIFEROUS GRAVELS.

To speak broadly, the auriferous gravels thus far discovered in the district fall into two zones which converge from lower Kougarok River. (See map, fig. 9, p. 165.) The larger zone, here termed the "Kougarok belt," stretches northward and embraces much of the Kougarok basin; the smaller zone, which appears less well defined, extends eastward to the Noxapaga, embracing the streams tributary to Kuzitrin River. This second zone will here be called the "southern belt." The Kougarok belt lies in a zone of schistose rocks, bounded on either side by the massive limestones. It furnishes, therefore, further evidence for the general law that the gold has its source at or near the limestone and schist contacts. Nor does the southern belt, so far as known, offer an exception to this rule. Each of these two belts embraces placers of the various types to be described below.

SOUTHERN BELT.

GENERAL DESCRIPTION.

The auriferous gravels forming a broken fringe along the southern margin of the highlands which bound the Kuzitrin basin on the north and west have certain features in common which justify the description of them as a unit. This belt includes the placers of Quartz and Garfield creeks, as well as those of the Noxapaga basin.

The bed-rock geology of this belt is obscured, both by the extensive alluvial deposits and by the products of deep rock decay. It appears however, that a belt of graphitic phyllites and schists, including some calcareous matter, stretches across the upland lying between Kaviruk and Kuzitrin rivers. In many places these rocks carry quartz veins, some of which are stained with mica and quartz. Schists occur north of the graphitic rocks, and still farther north these give way to a limestone. Though it is impossible to delineate these formations exactly because of the deeply weathered character of the rocks and the absence of outcrops, yet it appears that most of the gold-bearing creeks cross the contact of the limestone and schist.

The unconsolidated formations embrace (1) the present stream gravels, (2) the deposits flooring the Kuzitrin lowland, and (3) the bench gravels. Of the first group, which embraces most of the work-

[a] Not a single operator in the district responded to a request for information in reference to production.

ing placers of the district, little need be said, as they are fully described on page 168. Little can be added to the description of the second group already given. The terrace gravels merit some closer consideration.

It has already been indicated that the upland region falls off from an altitude of about 1,100 feet to the Kuzitrin Valley floor (100 feet above sea level) by a gentle slope, here and there broken by a more or less well-marked terrace. The best defined of these terraces lies about 100 feet above the present water level and is traceable from the mouth of Quartz Creek northward along the west side of Kougarok River to the point where the valley of the river emerges from the upland. A similar feature is found along the northern margin of the Kuzitrin lowland, and the lower part of Turner Creek and some of the tributaries of the Noxapaga are reported by Collier to be incised in deep gravel deposits, indicating an easterly extension of this same feature. Where exposed, the alluvium of which these terraces are made up is nearly everywhere seen to be composed of the same character of material—i. e., well-rounded and stratified brown sands and gravels. Certain exceptions to this will be noted below. There can be no doubt that these benches are the remnants of an extensive gravel sheet. In support of this view are the hillocks made up of stratified gravels which here and there stand above the floor of the Kuzitrin lowland.

Near the mouth of Quartz Creek the top of the terrace is about 125 feet above the water and the gravels rest on clay of unknown thickness about 15 feet below water level. The exposed material consists of well-rounded gravel and sand. On going up Quartz Creek the surface of the gravel is seen to dip with the grade of the stream, and a mile below Dahl Creek about 100 feet of gravel and sand is exposed in the valley wall. Above this point this bed was not definitely recognized, but it is believed to be represented by a white quartz gravel that is exposed on Quartz Creek just below the mouth of Dahl Creek. On the north side of Dahl Creek valley a shaft sunk to a depth of 180 feet was entirely in this white gravel and did not reach bed rock. It appears probable that these white gravels are a phase of the bench gravels of lower Quartz Creek and the Kougarok described above. The surface of these white gravels dips to the northwest under the trench occupied by Dahl Creek. In other words, the gravels underlying the pay streak at the Lane hydraulic mine and those of Dahl Creek are a part of the same bed. The surface of this same gravel deposit is believed to be exposed near the mouth of Joe Creek, a tributary of Quartz Creek. These relations are too complex to permit detailed analysis here, but they point to the following conclusions: (1) The auriferous gravels of the Lane hydraulic mine, Dahl Creek, and Joe Creek constitute the same horizon; (2) they are underlain by

alluvium, forming the white gravels of Dahl Creek and the bench gravels of the lower part of Quartz Creek and of the Kougarok, and these same gravels are found along the front of the upland near Garfield and Turner creeks; (3) this older gravel series is not believed to carry values, though it is known to be more or less auriferous.

This last conclusion is borne out both by the prospecting and by theoretical considerations. In general the rich placers of the peninsula occur in alluvium which is subangular and which was deposited under conditions of subaerial decay rather than during floods. These bench gravels are, however, well rounded and stratified and appear to have been laid down during periods of flood, which are not favorable to a concentration of values.

So far as known to the writer, the base of these gravels on bed rock has never been prospected. There is no reason to believe that the basement member may not be gold bearing, and in the opinion of the writer the chances of finding gold at depth is sufficiently good to warrant the outlay of the cost of prospecting them to bed rock.

Though it is not proposed to describe them in detail, a few notes on the different creeks will be appended.

COFFEE CREEK.

A peculiar auriferous deposit was opened up during the winter of 1906 on the upper part of Coffee Creek. Some rich placer ground was found in the angular talus of the valley slope, which appeared to be almost in place. The gold occurs in 4 to 7 feet of angular schist and quartz débris and weathered schist bed rock covered by 18 to 20 feet of muck. The quartz is iron stained, but does not appear to be auriferous, and the gold probably came from the schist. The gold is angular, spongy, and bright colored. These facts indicate that the material mined is the decomposed surface of a mineralized zone. The deposit has been traced about 1,000 feet, but being buried deeply its boundaries are not well known. It is indicative of the source of the gold and suggests at least the possibility of finding lode deposits which may carry values.

The other placers of the upper part of Coffee Creek are, as a rule, buried under an overburden of muck 10 to 20 feet thick. The gravels are chiefly schist and vary from 3 to 7 feet in thickness. Bench gravels similar to those of lower Quartz Creek occur near the mouth of Coffee Creek and are here said to carry some gold.

DAHL CREEK.

A bench at the mouth of Dahl Creek, 20 feet above the present stream bed, has been a large producer. A section at this point is as follows:

Section at mouth of Dahl Creek.

	Feet.
Muck	20
Ferruginous gold-bearing gravel	3–4
Sticky clay	$\frac{1}{2}$–1
Barren white quartz gravel.	

The section of the creek placers is practically the same, for as already stated the two horizons are believed to be identical. A mile and a half above the mouth the lower gravels give way to bed rock, and above this point but few values have been found.

QUARTZ CREEK.

Quartz Creek for half a mile below the mouth of Dahl Creek appears to have been worked out, for no mining has been done there for several years. As yet no values have been found below this point. Some placer ground has been developed at the mouth of Joe Creek, but the pay streak does not appear to be extensive.

TRIBUTARIES OF KUZITRIN RIVER ABOVE THE KOUGAROK.

This portion of the field, though the scene of profitable mining in the early days of the camp, has advanced but little in recent years. This is in part because the placers were found to be neither as extensive nor as rich as first believed and in part because of the high costs of mining due to the inaccessibility of the creeks.

Garfield Creek, from which $25,000 in gold was taken out during the first two years after its discovery, has been almost abandoned, though one claim continues to yield a little. The pay streak on this creek was narrow and thin and rested on a clay bed rock. Benches, though present, have not been found to carry values. So far as known, hard bed rock has never been reached in any of the operations.

Boulder Creek, a tributary of Turner Creek, has had a history similar to that of Garfield Creek. Little work has been done on it during recent years. From 3 to 11 feet of gravels are reported, with no bed rock. Deeper prospecting would appear to be justified. Among the smaller creeks in this vicinity on which gold has been found, but which have not been developed, are Grouse, Black, and Goose creeks.

NORTHERN BELT.

GENERAL DESCRIPTION.

The auriferous gravels of the main Kougarok above the Kuzitrin flats and of its tributaries form the northern belt of placers. The bed rock of this area is chiefly schist, but most of the tributaries of the Kougarok have their courses in limestone areas. This belt embraces stream placers and bench placers, of which the former type, to the present time, has yielded most of the gold. There are two forms of

stream placers—(1) those of the smaller gulches and creeks and (2) those of the main river. The gulch and creek placers are usually of small extent, but are so situated that many of them have been profitably mined by pick and shovel. On the other hand, many of the placers of the main river are of considerable extent and are difficult to exploit except with equipment that permits the handling of a large amount of material and provides for both high-water and low-water conditions.

Bench gravels have been reported at various localities, but those of proved economic importance are confined to the main Kougarok River and some of its larger tributaries. These are chiefly within 25 feet of the present water level, but some higher benches are reported to be auriferous.

KOUGAROK RIVER.

The Kougarok is a swiftly flowing stream carrying at its mouth 10,000 to 15,000 inches of water and having an average gradient of about 20 feet per mile. Most of the material transported is coarse, varying from fine gravel to coarse cobblestone.

Undoubtedly the most extensive deposit of auriferous alluvium yet found in the district is that of the main Kougarok, occurring both in the present stream bed and on the benches. For at least 40 miles of its course the gravels of this stream have been found to be auriferous, though it is impossible to state at present what part of these carry commercial values. The valley of the Kougarok has a meandering course and varies greatly in its cross section. In some places it is steep walled, narrow, and without benches; in others it opens out into a broader basin, with gentle slopes or bounded by well-marked rock benches. A striking feature of its topography consists of the various levels of erosion, which are marked by benches both along the main river and along many of its tributaries. These clearly indicate a succession of uplifts that have brought about the incision of former valley floors, remnants of which are preserved as benches. Evidences were observed of at least three of these uplifts, of which naturally the last is best preserved, and consists of a rock bench covered by gravels standing 15 to 25 feet above the present water level. Where the Kougarok enters the Kuzitrin lowland both valley walls show well-marked benches. Two levels are here marked—one at 50 feet and one at 25 feet. These are traceable for about a mile and a half above Windy Creek; then the walls become steeper, and as far as Left Fork the river occupies a canyon-like valley. From this point to Washington Creek, 20 miles above, some evidence of benching can be observed at most places, though it is not intended to imply that the benches are continuous. The individual benches have not been traced, but in that part of the valley which lies below Taylor Creek there are at least two levels and possibly three.

Some of the placers of the present stream bed have been worked spasmodically since the discovery of the district. A little gold has been taken out of the river bed with shovel and rockers near Coarse Gold Creek and at various points as far as Taylor Creek. Much more work has been done at and above the big bend of the Kougarok, near the mouth of Macklin Creek, and as far as Washington Creek. Mining was necessarily confined to low-water stages. These placers are in no sense of the river-bar type, as they carry coarse gold mingled with gravels and concentrated to a large degree on bed rock.

The river gravels in their upper part are usually well rounded and stratified, but the pay streak near bed rock is in many places made up of subangular material. The largest pebbles are usually not over 1 or 2 feet in diameter, but a few bowlders of greater size, which have been contributed by the talus of the valley slopes, are encountered. No general statement of the thickness of the gravels can be made, as it varies greatly in different parts of the river. In the canyon previously described bed rock is exposed throughout the river bed. In many places above the canyon gravels are almost entirely absent, while in other places the depth to bed rock is 6 to 20 feet.

The width of the alluvial floor also is variable, for in some parts of the river the entire valley floor is buried in gravels, and in others the stream has uncovered bed rock over a part of the floor. The actual flood plain of the river varies from 100 to 800 feet in width. Where the river enters the flat it is about 800 feet wide; in the canyon, about 100 feet; at the mouth of North Fork, about 300 or 400 feet; at the mouth of Taylor Creek and near the mouth of Trinity Creek, about 300 feet.

Below the flat at the mouth of Taylor Creek the alluvium is almost entirely made up of gravel; above that point the gravels are in places buried under considerable muck.

So far as known to the writer the gold found in the stream bed below Coarse Gold Creek is chiefly fine, but at the mouth of this creek and above it considerable coarse gold is reported. This fact is important, because it indicates that in the upper half of the river enrichment has taken place from local sources and that the gold has not all been brought in by the main stream from its headwaters. Coarse gold is, however, reported to occur at the mouth of North Fork.

The gold of the flood plain is usually of a dark color; that of the smaller tributaries is bright. Thus far the only placers of the flood plains that have been opened up on a commercial basis are those at the mouth of North Fork, where little has been done, at the mouths of Taylor and Homestake creeks, and between Macklin and Washington creeks.

The bench deposits of the Kougarok appear to afford an attractive field for the gold miner. Their position makes them easy of access, and no hydraulic lifts are required to dispose of the tailings. These benches can not be described in detail, because the facts are wanting. Between Coarse Gold and Taylor creeks the benches are particularly well defined, and there are at least two distinct levels about 25 and 50 feet above the water. So far as observed the gravels are from 8 to 10 feet in depth and are usually covered with muck. No determinations of values are known to the writer, but the fact that some gravels of the lower tier have been worked at a profit by crude methods makes it seem probable that their gold content is not inconsiderable.

Bench gravels have been reported at various places above Taylor Creek, and some are known to be auriferous, but they have not been developed on a commercial scale.

This rather fragmentary evidence points to a wide distribution of gold along the main Kougarok and to the presence of values at many places in both the bench and the flood-plain gravels. From the existing knowledge it appears that this valley contains the largest gold reserve of the district.

WINDY CREEK.

The developed placers on Windy Creek occur in a small tributary from the south called Anderson Gulch, which is a minor depression in the valley wall. The gravels exposed in the cuts are 2 to 3 feet thick. In addition to this 1½ to 2 feet of bed rock is put through the sluice boxes. The bed rock is a silvery mica schist with much iron-stained quartz. These placers have been traced for 1,600 feet along the slope of the valley of Windy Creek. The known area of workable deposits is not large, but as gold has been found in other parts of the basin other placers will probably be found.

NORTH FORK.

The basin of North Fork was the scene of the first gold discoveries in the Kougarok district, and some of the placers have yielded a considerable output of gold. A marked feature of its topography are the benches, of which three different tiers are known. The bed rock of the basin includes both schists and limestones.

Workable placers have been found on the main stream and on Harris Creek, and gold is reported from the gravels of Eureka Creek and a number of other small tributaries. The evidence at hand indicates that this basin will become an important producer.

COARSE GOLD AND OTHER SMALL CREEKS.

The alluvium of Coarse Gold Creek is auriferous, but as yet only small amount of gold has been extracted. A hard diorite forms ıe bed rock of a part of the creek and does not afford a favorable ırface for the concentration of values. The lower part of the creek in schist and deserves attention on the part of prospectors.

Arizona and California creeks are small streams, but they have ›nsiderable gravel deposits near their mouths. Both the flood-lain and bench deposits have yielded considerable gold.

Gold was discovered on Henry Creek about five years ago, but the alues do not appear to be great. Little has been done on this ream since 1903.

Between Coarse Gold and Taylor creeks there are a number of small ılches which have yielded values, but these will probably be mined ith the bench deposits already described and deserve no special ıention here.

TAYLOR, HOMESTAKE, AND OTHER CREEKS.

Taylor Creek is the largest tributary of the Kougarok. In its asin are exposed both limestone and schists. Some mining has een done near the mouth of the creek, where the placer deposits are milar to the flood-plain deposits of the Kougarok, of which they ›rm an extension. Above this point the only mining attempted ı this basin is on a small tributary called Solomon Creek. At the ıouth of this stream there is a sloping bench on which lie 3 to 7 ›et of gravels covered by 8 to 10 feet of muck. These gravels are ıriferous and have been mined in a small way, as have also the ream gravels of Solomon Creek half a mile above.

Auriferous gravels have been found throughout the length of [omestake Creek, and the claims near the mouth have produced ›me gold. The auriferous gravels are from 5 to 8 feet thick, and ay streaks to a width of 40 feet have been found.

Among the smaller tributaries above Homestake Creek which have ielded values are Macklin, Trinity, and Mascot creeks. These reams contain no extensive deposits, but include some workable ravels, whose occurrence is of significance in showing a wide distri-ution of the gold.

CONCLUSIONS.

The investigations on which this report is based were entirely ɔo inadequate to permit a final word on the value of the auriferous ravels of the district. That there are extensive alluvial deposits arrying sufficiently high values to yield adequate returns for eco-omic mining no one can deny who has studied the matter carefully.

It is equally well known that as yet, with the exception of a few claims no gravels of very high grade have been developed. Certain conditions already referred to are favorable to the probable extension of the placer-mining industry. One of these is the wide extent of the mineralization. If, as stated elsewhere in this report (pp. 25, 130–132) the zones of mineralization of the peninsula are most commonly found along or near the contacts of mica schist and limestone, the Kougarok is a region where placers should be expected. As in other mineral-bearing districts of the peninsula, the bed rock is closely folded faulted, and fractured, and mineralized quartz stringers are not uncommon, but have not been tested as to their gold content. In at least two localities the gold has been traced to its bed-rock source in the schists. So far as the present studies can determine, the bed rock is no less favorable for the occurrence of gold here than in other districts of the peninsula.

The history of this province since it was last elevated above the sea, interpreted according to theories elsewhere presented, favors the concentration of gold in the alluvial deposits. The various epochs of erosion indicated by the bench deposits would promote the concentration of the heavier materials in the gravels. In several localities on Kougarok River the gold was probably derived by reconcentration from older elevated placers. Yet it must be said that, in spite of this reconcentration, the resulting placers have not been found to be as rich as those of similar origin in other parts of the peninsula. This fact points toward the conclusion that the bed-rock source is not as heavily mineralized as in some of the other districts. The lower bench gravels of the Kougarok and some of its tributaries are undoubtedly among the most important deposits of the district, if only because of their favorable position for cheap mining. The highest gravels (i. e. those above 50 or 60 feet) reported at various places have now little prospect of development unless they are far richer than any of the other deposits. Their topographic position makes it difficult, if not impossible, to hydraulic except at great cost. Experience has shown that the abundance of the ground ice, the limestone masses, and heavy talus all combine to make ditch construction and maintenance expensive.

The writer is unable to make a definite statement of the gold tenor of the gravels in this field, for the results of the little prospecting that has been done have not been available for the purposes of this report When the meager evidence is carefully weighed, it seems probable that $2 to the cubic yard must be considered high value for most of the placers of the district. Whether or not there are considerable bodies of gravel which carry such values, the writer is not prepared to state While a gold tenor of $2 would be considered very rich in most placer camps, it is low compared with that of some of the auriferous gravel

f Anvil and Ophir creeks. Nevertheless, there is no doubt that ravels can be profitably mined at but a fraction of this amount in nany places in this district.

The two dry summers, 1900 and 1906, make it evident that such limatic conditions must be reckoned with in counting cost, especially here large investments of money are made. Though during a wet eason there is an abundance of water, nevertheless the Kougarok has o such reservoirs to draw on as the Kigluaik Mountains, which are eing tapped by the Nome ditches, and this fact is emphasized by a ry season like that of 1906. At the rate that ditch building is going n every possible source of water supply will soon have been utilized. Iere, as elsewhere, more careful prospecting of the ground would robably have curtailed some of the ditch building. It appears that ome operators have been too ready to believe without adequate prosecting that the values in the ground were sufficient to warrant large xpenditures for ditch construction. This hit-or-miss style of mining as fewer odds against it in regions where the hope of finding bonanzas s better than in the Kougarok. It certainly can find no place in a egion where the question of costs has to be carefully considered.

The Kougarok does not appear to be an inviting field for the miner without capital. Though considerable gold has been recovered by ick and shovel, on the whole the values thus far developed are not igh enough to yield profits by such simple methods of mining. This s certainly true now, but conditions may alter with the reduction of osts of labor and supplies.

To recapitulate briefly, the following facts appear to be established: (1) Prospecting up to the present time, so far as known to the writer, has not established the existence of many bonanzas. (2) There are some extensive deposits of heavy auriferous gravels, yet it appears that but few of them have been sufficiently prospected to prove their values. (3) Water is far from abundant, but, in many localities during most seasons, is probably sufficient. (4) Mineralization, however, is widespread, as is also the gold in the alluvium. (5) Some of the bench deposits are very favorably located for profitable exploitation by hydraulic methods. (6) There is probably some ground which can be dredged, but as yet few facts in regard to it are available.

In the opinion of the writer the Kougarok district will become one of the important gold producers of the peninsula, though it is not to be expected that its output will ever be comparable to that of some of the older districts, such as Nome and Ophir Creek. It is a field where profits can be expected only by a careful counting of costs and conservative business management.

WATER SUPPLY OF NOME REGION, SEWARD PENINSULA, 1906.

By J. C. Hoyt and F. F. Henshaw.

INTRODUCTION.

The economic working of the richer placer deposits in all portions of Alaska depends largely on the amount of water available for both washing and hydraulicking the gold-bearing gravels. The scarcity of water has led to extensive ditch construction, which has often been undertaken with but little exact information in regard to the available water supply. Many of these hydraulic works have been either financial or engineering failures, owing to insufficiency of water, and some of these failures could have been averted had reliable hydrographic data been at hand.

For this reason the United States Geological Survey started systematic measurements of the flow of Alaska streams during the summer of 1906. Owing to the smallness of the funds available the work was confined to Seward Peninsula, and especially to the streams from which water could be taken for working the rich placers near Nome, as shown on the Nome and Grand Central special topographic sheets. This area was chosen for investigation on account of its extensive operations.

These investigations consisted in (*a*) determining both the total flow and the distribution of the flow of various streams during the mining season; (*b*) collecting facts in regard to general conditions affecting water supply; and (*c*) gathering statistics in regard to the diversion and use of water.

GAGING STATIONS.

Measurements of discharge were made at the forty-five different gaging stations named in the subjoined list. Most of these stations are on streams so located as to be available for the placer gravel near Nome.

Gaging stations on Seward Peninsula.

1. Nome River above Miocene intake.
2. Buffalo Creek.
3. Dorothy Creek.
4. Miocene ditch at Black Point.
5. Miocene ditch at flume.
6. Hobson Creek at Miocene ditch crossing.
7. David Creek ditch intake.
8. Seward ditch intake.
9. Grand Central River (North Fork) at elevation 750 feet.
10. Grand Central River (North Fork) at elevation 1,030 feet.
11. Grand Central River (West Fork) at elevation 860 feet.
12. Grand Central River (West Fork) at elevation 1,010 feet.
13. Crater Lake outlet.
14. Grand Central River below forks.
15. Grand Central River below Nugget Creek.
16. Gold Run.
17. Thompson Creek.
18. Nugget Creek.
19. Copper Creek.
20. Jett Creek.
21. Morning Call Creek.
22. Kruzgamepa River at outlet of Salmon Lake.
23. Crater Creek.
24. Iron Creek below mouth of Canyon Creek.
25. Iron (Dome) Creek.
26. Eldorado Creek.
27. Discovery Creek.
28. Canyon Creek.
29. Sinuk River.
30. Windy Creek.
31. North Star Creek.
32. Stewart River.
33. Slate Creek.
34. Josie Creek.
35. Irene Creek.
36. Jessie Creek.
37. Upper Oregon Creek.
38. Slate Creek.
39. Aurora Creek.
40. Penny River at elevation 420 feet.
41. Penny River at elevation 120 feet.
42. Eldorado River.
43. Fall Creek.
44. Glacier Creek.
45. Snow Gulch.

MEASUREMENTS.

The detailed results of these measurements are given in Water-Supply Paper No. 196, from which the accompanying tables, indicating the general conditions, have been taken. Table 1 shows the mean weekly water supply available during 1906 for use back of Nome. Table 2 gives the mean monthly run-off per square mile

above various stations. Table 3 gives the minimum flow for streams rising in the foothills and in the mountainous regions. These tables not only show the amount of water available in the area under investigation, but also give a basis for estimating the possible water supply to be had in other similar areas.

TABLE 1.—*Mean weekly water supply, in second-feet, available for use back of Nome, 1906.*

Date.	Available for use at elevation 250 to 275 feet, Nome River low level.	Available for use at elevation 400 to 450 feet.				Total.
		Nome River high level.	Upper Grand Central River, Thompson Creek, and Gold Run.	Nugget, Copper, and Jett creeks.	Sinuk River, Windy and North Star creeks.	
July 1-7	31	45	153	7	88	324
July 8-14	110	144	343	26	173	796
July 15-21	36	58	179	15	90	378
July 22-28	29	49	156	12	79	325
July 29-August 4	22	42	101	8	50	223
August 5-11	26	45	108	8	49	236
August 12-18	34	53	91	8	42	228
August 19-25	58	84	138	10	62	352
August 26-September 1	94	128	202	22	94	540
September 2-9	48	73	101	14	51	287
September 9-18	33	53	68	9	36	199
September 18-30	86	118	250	20	125	599
Mean	51	74	158	13	78	375
Maximum	110	144	343	26	173	796
Minimum	22	42	68	7	36	199

TABLE 2.—*Mean run-off at various gaging stations on Seward Peninsula.*

Station.	Drainage area (square miles).	Mean run-off (second-feet per square mile).				
		July 1-31.	July 1-4 and 11-31.	August 1-31.	September 1-30.	September 1-18.
Grand Central River (North Fork), elevation 750 feet	5.4	....	[a] 7.53	[a] 6.80	....	5.85
Grand Central River (North Fork), elevation 1,030 feet	2.3	....	....	11.9	....	9.65
Grand Central River (West Fork), elevation 860 feet	5.4	....	10.3	6.02	....	4.72
Grand Central River (West Fork), elevation 1,010 feet	2.8	....	9.64	4.96	....	3.36
Crater Lake outlet	1.8	....	10.8	6.56	....	2.89
Thompson Creek	2.5	....	8.20	6.64	....	3.04
Grand Central River below the forks	14.6	....	8.36	5.84	....	4.25
Grand Central River below Nugget Creek	39	....	....	[a] 4.42	....	3.36
Kruzgamepa River at outlet of Salmon Lake	81	7.05	....	3.20	5.63	3.05
Between Grand Central River below the forks and Kruzgamepa River stations	66	....	....	2.62	....	2.79
Nome River at Miocene intake	15	3.43	2.71	3.36	4.29	....

[a] Approximate.

TABLE 3.—*Minimum flow of streams in Seward Peninsula.*

STREAMS RISING IN FOOTHILLS.

Stream.	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum run-off per square mile.
	Feet.		*Sec.-feet.*	*Sq. miles.*	*Sec.-feet.*
ron Creek below mouth of Canyon Creek....	450	Aug. 14....	17.1	37	0.46
ldorado River below mouth of Venetia Creek.	400	.....do.....	44	51	.86
ett Creek....	800	Sept. 10....	[a] 4.2	1.4	3
opper Creek....	800	Aug. 11....	.8	.85	.94
ugget Creek....	785	June 28....	[b] .96	2.1	.46
avid Creek....	590	Aug. 19....	3.3	4.3	.77
orothy Creek....	500	Aug. 18....	2.9	2.7	1.1
obson Creek....	500	July 4......	10.5	2.6	[c] 4
late Creek (tributary of Stewart River)....	700	Aug. 19....	2.2	2.1	1.05
tewart River....	400	.....do.....	11.4	36	.32
enny River....	120	Aug. 1.....	[a] 36	19	1.9

[a] Lowest measurements obtained. The flow was less on certain dates.

[b] The lowest flow later in the season was 3.0 second-feet, or 1.4 second-feet per square mile on August 1.

[c] The flow of Hobson Creek is from large limestone springs whose catchment area may not coincide ith the surface drainage basin.

STREAMS RISING IN KIGLUAIK MOUNTAINS.

Stream.	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum run-off per square mile.
rand Central River (North Fork)..........	750	July 1......	23	5.4	4.3
rand Central River (West Fork)...........	850	Sept. 15-17.	19	5.4	3.5
rand Central River below the forks..........	690	Sept. 16-17.	47	14.6	3.1
rand Central River below Nugget Creek....	455	.....do.....	90	39	2.3
etween Grand Central River below the forks and station at Nugget Creek.	....	.....do.....	43	24.4	1.76
rater Lake outlet....	925	Sept. 15-17.	3.1	1.8	1.7
hompson Creek....	720	Sept. 16-17.	5	2.5	2
indy Creek....	650	Aug. 3.....	32	12	2.7
orth Star Creek....	900	Aug. 10....	2.9	2.3	1.26
inuk River....	770	Aug. 3.....	20	6.2	3.2
uffalo Creek....	800	.....do.....	9.1	4.4	2.1
ome River....	575	Aug. 5.....	20	15	1.3
ox Creek....	550	Aug. 16....	17.3	11	1.6
rater Creek....	550	Sept. 16-17.	39	....	....
ruzgamepa River....	442	Aug. 19-Sept. 17.	175	81	2.16

RAINFALL.

In connection with the stream gaging, four rainfall stations were stablished, as follows: Nome, claim No. 15, on Ophir Creek, foot of almon Lake, and Deering. Records were received only at the first hree stations, where the mean monthly rainfall was as follows:

Mean monthly rainfall, in inches, at stations on Seward Peninsula, 1906.

Station.	June.	July.	August.	September.	Total, June to August.	Total, June to September.
ome....	Trace.	2.38	2.50	1.02	4.88	5.90
almon Lake....	Trace	4.92	3.33	3.26	8.25	11.51
phir....	Trace.	3.57	1.91	([a])	5.48	....

[a] No record.

The following statement gives briefly the climatic conditions existing in this area during the years 1899-1906:

1899. July, four rainy days; August, fourteen rainy days; September, fourteen rainy days; recorded at Teller.

1900. June and July, warm and dry, tundra fires common; August to end of September, rain.

1901. June to August, inclusive, cold and foggy with some rain; September and October, usually clear and cold with one or two hard rains of a few days' duration.

1902. June, dry; July, ten rainy days; August, six rainy days; September, three rainy days; recorded at Teller.

1903. Summer warm; little rain, but considerable fog.

1904. June, dry; rainy days as follows: Ten in July, ten in August, ten in September; temperature moderate.

1905. Very wet and cold the whole season.

1906. Very warm and dry; tundra fires common; maximum temperature 85°.

THE CIRCLE PRECINCT.

By Alfred H. Brooks.

INTRODUCTION.

The gold-bearing area tributary to Birch Creek, in the central Yukon region, is usually known as the Birch Creek district.[a] Birch Creek lies, for the most part, in the so-called "Circle precinct," which embraces the Birch Creek and Preacher Creek basins, as well as Woodchopper and other small gold-bearing streams. This whole region is tributary to the town of Circle, which is located on the west bank of the Yukon and contains several hundred inhabitants.

Means of communication are very inadequate throughout this region. Freight is delivered at Circle or other points by steamer in the summer and during the winter months is hauled to the various placer mines, distances varying from 10 to 50 miles, at a cost of 3 to 6 cents a pound. Wagon roads are almost entirely lacking, and during the wet weather of the summer the horse trails become well-nigh impassable. A system of wagon roads is the first need of this region. The difficulties of communication are also rendered greater here than in some of the other inland placer districts by the entire absence of telegraph or telephone lines.

In spite of the adverse conditions, the Birch Creek district stands to-day as one of the few placer camps which have been developed entirely without the aid of outside capital. Since the discovery, in 1894, step by step, through the efforts of the miners who have taken their capital out of the ground, advances have been made. Though this is one of the last of the Alaskan mining fields to be invaded by capital, this change is now in progress, for during 1906 several groups of claims passed into the hands of strong companies. This will eventually revolutionize mining methods and bring about a great increase of production. As the installation of mining plants will require several years, however, the production meanwhile will decrease.

The following notes are based largely on the writer's own observations during a journey in 1906 along the Yukon and through the Birch Creek district, which occupied about a month, but free use has

[a] "District" has no legal significance as a territorial subdivision, for the units are officially known as precincts.

been made of the publications of Prindle,[a] who has already described the general features of the geology and topography, and these will not be redescribed except so far as is necessary to an understanding of the description of the placers. The uniform courtesy and hospitality shown to the writer throughout the region greatly aided the investigation.

STATISTICS.

Data in regard to the gold production of this region are exceedingly scant, but the following estimates are based on the best evidence available. The error in the tables may be as great as 10 or 15 per cent.

Approximate value of gold production of Birch Creek district, 1894–1906.

1894	$10,000	1902	$200,000
1895	150,000	1903	200,000
1896	700,000	1904	200,000
1897	500,000	1905	200,000
1898	400,000	1906	300,000
1899	250,000		3,560,000
1900	250,000		
1901	200,000		

Estimated value of gold production of Birch Creek district, by creeks.

Deadwood Creek[b]	$700,000
Mastodon and Mammoth creeks[b]	2,060,000
Eagle Creek[b]	600,000
Other creeks[b]	200,000
	3,560,000

The first three areas in the foregoing table continue to be the largest producers, probably in about the ratio of total output there given. Of less present importance, but also productive, are Harrison, Miller, Greenhorn, Woodchopper, and Fourth of July creeks. Gold has also been found on a number of other streams which have yielded only a small production and are too numerous to mention. It is estimated that values have thus far been found along a total length of 23 miles, but it is impossible to state what proportion of this pay streak has been worked out. There are but few claims in the entire district that have been entirely worked out, and, in fact, even these will, to a certain extent, probably be reworked by improved methods. In 1906 there were about 200 men at work in the district on about 60 to 100 claims.[c] Most of the mining was by pick and shovel methods, but one small hydraulic plant was operated on Harrison Creek and another with a steam scraper on Mastodon Creek. There were also

[a] Prindle, L. M., The gold placers of the Fortymile, Birch Creek, and Fairbanks regions: Bull. U. S. Geol. Survey No. 251, 1905; Description of the Circle quadrangle (one of a series on the Yukon-Tanana region): Bull. U. S. Geol. Survey No. 295, 1906.

[b] With tributaries.

[c] Claims are 500 feet long in Birch Creek district.

a number of steam bucket hoists. Winter work is now usually done with the aid of steam thawers.

The placers here to be described fall into two groups that differ both geographically and geologically—(1) placers lying within the Birch Creek basin and (2) those along streams which discharge directly into the Yukon. The gold of the first group is derived from mica-schist and quartz-schist bed rock; that of the second group is, in part at least, derived from a conglomerate, where it is of secondary origin.

BIRCH CREEK BASIN.

GENERAL GEOLOGIC FEATURES.

The known auriferous portion of the Birch Creek basin embraces primarily those streams which head in an irregular northwest-southeast trending ridge, of which Mastodon (4,500 feet) and Porcupine (4,900 feet) domes form the highest summits. The radial arrangement of the gold-bearing streams from this watershed is a striking feature and is suggestive of the location of a zone of mineralization.

Schistose quartzite and mica schist form the prevailing bed rock throughout the area. Locally these rocks are found to be feldspathic, and these phases may be altered intrusives, but for the most part the formations appear to be of sedimentary origin. The rocks are closely folded and much sheared, and the prevailing strikes are east and west. Granite intrusives are not uncommon. Notably on Deadwood, Mammoth, and Miller creeks there are considerable areas of this rock. The central parts of the intrusives appear to be massive, but along some of their margins the writer observed evidence of deformation. Whether this is generally true he was unable to determine. Prindle has described some diabase dikes which occur in this region, but none came under the observation of the writer.

A general wide distribution of vein quartz is attested both by the bed-rock exposures and by the character of the fluvial deposits. This quartz is very frequently found to be iron stained, and one naturally turns to it to seek a source of the placer gold. There is but little direct evidence on this point. The presence of pyrite-bearing vein quartz in the auriferous alluvium is a characteristic feature of these deposits. On Eagle Creek a 4-foot gold-bearing quartz vein is said to have been encountered in the drift mining, but the writer did not see the exposure, as the drift had caved in. A specimen of the quartz showed it to be iron stained and broken by thin seams of gold. The gold of the adjacent placer was angular and carried much quartz. A mineralized fracture zone about 8 inches in width has been found on the upper part of Deadwood Creek. Within this zone the schist is permeated by stringer veins

carrying pyrite and galena, and it is reported to carry values of $6 in gold and $8 in silver.

Spurr[a] reported the finding of gold-bearing quartz on Harrison Creek. He describes the occurrence as follows:

> The best example of gold-bearing quartz found in the gravel is a rhomboidal block of quartz schist, about 4½ by 5 by 2 inches, found on claim 91, on North Fork, about three-quarters of a mile above the forks. On one of the larger surfaces of this block is a quartz vein which is richly spotted with flakes and specks of gold, ranging from three-sixteenths of an inch in diameter to mere specks, which finally become invisible to the naked eye.

These facts indicate that the placer gold is derived from zones of mineralization in the schist series. The wide distribution of the placer gold is not a favorable indication that the values are sufficiently localized in the bed rock to afford commercial ore bodies. It must be said, however, that there is little evidence on this point, and workable lodes may yet be found when a systematic search is made.

The alluvium, like the bed rock, varies in character. Nowhere was any foreign material observed in the stream gravels, and as a rule there is a progressive increase in size of material toward the headwaters of any given watercourse. Where mining operations have been carried on the extreme depths to bed rock usually do not exceed 20 to 30 feet and probably do not average more than 8 feet. In most sections the material becomes very angular toward bed rock. The bed rock itself is in general deeply weathered, and the material excavated usually includes 2 or 3 feet of it. Along nearly all the creeks one or more benches occur on the valley slopes. Those that have been found to carry values are from 2 to 20 feet above the present stream floors. The character of the alluvium on the benches is similar to that of the valley bottoms, but much of it is deeply buried under talus, or "slide rock," as the miners call it. This talus has in many places so obscured the original topography that the benches are not found until they are developed by mining excavations. At several localities the writer observed still higher benches, 40 to 50 feet above the present stream floors, but these appear to be very local, and even if found to be auriferous are beyond the reach of the present water supply.

A feature repeatedly observed in this province by Prindle is the asymmetrical character of the valleys when viewed in cross section. One wall is usually steep, with benches entirely absent, while the other has a gentle gradient and is broken by numerous benches. The miners have taken cognizance of this fact in their prospecting, which has been devoted chiefly to the gentle slopes where the old channels and benches, if present, would be preserved.

[a] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 353–354.

The gold-placer deposits vary so greatly as to dimensions that few general statements can be made. In fact, the width and the thickness of the pay streak vary according to the cost of extracting it. For example, if values of $2 to the cubic yard are the lowest that can be profitably mined, as is probably the case with present usage in mining throughout most of the district, it puts a limitation on the dimensions of the pay streak quite different from what it would be if the costs were reduced to $1 per cubic yard. It is therefore very difficult to make any broad statement relative to the pay streak.

Throughout the gold-bearing region the alluvium can be said to be auriferous, inasmuch as it usually carries enough colors of gold to be found by the ordinary methods of panning. On the other hand, the pay streaks as now mined (i. e., with a probable minimum value of $2 to the cubic yard) are confined to certain creeks and to certain channels in the creek floor or on the benches. With these limitations it is probably fair to state that the pay streaks do not average more than 40 or 50 feet wide through the district, though on some creeks, notably on Mastodon, a width of over 200 feet has been mined at a profit. Probably few single pay streaks are traceable for more than 1,000 or 2,000 feet, though a succession of them may give practically a continuous zone of placers for several miles.

The same limitations must be placed on any statement in regard to thickness. Gold may be distributed through the entire thickness of gravels, but appears to be more commonly concentrated in the 2 or 3 feet next to bed rock. It is usually found to a varying depth in the weathered bed rock. In general it appears to be true that where the gravels are well rounded the gold is more uniformly distributed than where the material is angular, but in the first case the values per cubic yard are likely to be less.

Most of the rich pay streaks have a lenticular form, with their longer axes parallel to the trend of the stream valley. The pay streak may be straight or may wind from one side of the valley to the other. It is more likely to be straight in the broader valleys than in the smaller ones. If the valley is asymmetrical, the pay streak may be crowded to the steep wall by the talus which comes down the gentle slope. The talus may also bury an older channel.

In distribution the gold follows the same general law as the gravel, being coarsest at the points farthest upstream and gradually becoming finer downstream. The several exceptions to the rule noted only prove that the gold has in some places a very local source, being probably derived from mineralized zones which cross the drainage courses.

The average value of the gold of the Birch Creek basin, as reported by operators, is $17.73 per ounce, the Eagle gold being the purest and Deadwood the most impure.

Prindle has described the various creeks in detail, and it will not be

necessary here to repeat the descriptions. A few notes on development will, however, be appended. Harrison Creek w ll be described in more detail, as it has been developed since Prindle's studies were made.

NOTES ON DEVELOPMENT.

BIRCH CREEK.

The bars along Birch Creek have been found to be auriferous and were, in fact, the scene of the first discoveries of gold in the district. During low water some gold has been taken out of these bars with the aid of rockers. The wide extent of these deposits, their probably unfrozen condition, and the absence of bowlders have attracted the attention of those seeking dredging ground. It should be noted, however, in considering this form of deposit that the richness of the bars is not a criterion of the gold contents of the deeper alluvium. In the river bars the gold is in a concentrated form, and the balance of the alluvium may be almost barren. As there has been no excavation to bed rock in these large streams nothing is known of the depth of the alluvium or the values in it. Extensive prospecting with churn drills should precede the installation of dredges.

DEADWOOD CREEK.

One hundred and six 500-foot claims have been staked on Deadwood Creek and more or less work has deen done on 67 of these. Gold has been found in commercial quantities from a point about a mile above the mouth throughout the length of the creek, a distance of nearly 9 miles. One considerable tributary, Switch Creek, has also yielded values. Nearly all the mining on Deadwood Creek has been carried on by small operators and by simple methods. Many a prospector who has been on the creek since its discovery has never attempted to gain more than a living wage from his holdings, and the creek can be called a stronghold of conservatism.

In the lower mile of its course the Deadwood Creek valley broadens out and gradually merges with that of Crooked Creek, and here the values are more disseminated than they are above and, therefore, are not susceptible to profitable exploitation by the crude hand methods. This part of the field is worthy of careful examination by those looking for dredging ground. Though it may be unsafe to predict the probable conditions to be encountered, yet the following suggestions can be made. It is very likely that the bed rock is slabby quartzite schist or soft mica schist, with possibly some granite. Probably the values are considerably disseminated, and it is not to be expected that the gold will be coarse. The alluvium will probably be found to be made up chiefly of well-rounded gravels, and it is, therefore, quite possible

hat there are considerable areas of unfrozen ground. There is no neasure of the thickness of the alluvium below a point one-half mile bove the mouth of the valley, where it was only 10 feet to bed rock. Iowever, it does not seem probable that the bed-rock floor slopes more han 25 feet to the mile, and, therefore, it is not to be expected that he alluvium will be found to be more than 35 feet thick.

Among other improvements which will undoubtedly come is the vorking of large groups of claims instead of individual holdings. There is no doubt that if the entire creek could be worked by one comany there would be a great economy in costs and a greater percentge of the values could be recovered. There appears to be little ope of obtaining water outside of the basin, but the creek itself furishes an adequate supply in most seasons for at least one large peration.

The gold output for 1906 is estimated to have been about $120,000 n value, less than 50 per cent of which was taken out by winter rifting. It is estimated that 11 claims were worked during the vinter by 35 men and 13 claims during the summer by 60 men.

BOULDER CREEK.

Though the gravels of Boulder Creek are auriferous, as would be xpected, for it lies in the gold-bearing zone, yet so far the only lacer values found have been on a small tributary called Greenhorn reek. Here the gravels are only 4 feet deep, but although they arry good values, the lack of water often prevents mining during nuch of the open season.

MAMMOTH CREEK.

Mammoth Creek, which is formed by the junction of Independence nd Mastodon creeks, has a broad flood plain, being 100 to 500 yards vide. The bed rock is probably chiefly schist, but in part granite. The granite yields some large bowlders; the schist is as a rule deeply ecomposed. The bed-rock floor slopes at a very low angle. The lluvium is probably 10 to 15 feet deep, and is made up of rather wellounded material, much of which is frozen. In the excavations, owlders of 2 to 2½ feet are not uncommon, and some 3 to 4 feet in iameter were observed. The gold is reported to be fine and its disribution fairly uniform. Mammoth Creek has not been the scene f much mining except at its head and about halfway to its mouth. t the latter place a small steam shovel was installed and a pit of about ,000 cubic yards capacity excavated some years ago. This was an xperiment and the results are said to have been satisfactory to the perators. In 1906 the creek was under examination by dredging nen, who seem to be justified in considering this dredging ground.

INDEPENDENCE CREEK.

Considerable gold has been taken out of Independence Creek, bu during the last year there were only a few operators at work. At it mouth the valley floor is about 100 yards wide, but narrows rapidl in going upstream. The pay streak appears to be irregular and swing from one side of the creek to the other. The gravels are from 3 to feet deep. There are some well-defined benches along the creek In 1906 some work was done at half a dozen claims on this stream but the aggregate output was small.

MASTODON CREEK.

Mastodon Creek contains the richest gravels yet discovered in th district and has been by far the largest producer. The bed rock i practically all quartz and quartz-mica schist, with many quart veins. At the mouth of the creek the valley floor is about 400 yard in width and gradually narrows down to about 200 yards 2 mile above. The lowest 2 miles of the valley are the richest and contai the largest pay streak, which is about 200 feet wide and 7 to 10 fee thick. In this part of the creek there are well-defined benches som of which have yielded rich placers on the northwest valley slop About 2 miles from the mouth the walls are steep and apparentl have no benches, while the pay streaks are narrower and not so thicl

A part of the alluvium on Mastodon Creek is frozen and therefo could not be dredged unless the ground were first thawed. There ar however, considerable areas that are not frozen. The tailings fro former mining operations probably contain enough gold to pay f rehandling with a dredge. The grade of the major portion of tl stream is 100 or 200 feet to the mile.

Mining was actively pushed throughout the greater part of tl creek during 1906. Most of the operations were by shoveling in sluice boxes, but several steam hoists and one small hydraulic pla with steam scraper were in operation. It is reported that conside able property changed hands during the year preparatory to mo extensive operations.

MILLER CREEK.

Miller Creek, though never a large producer, has been work more or less continuously since 1895. Its bed rock is chiefly schi similar to that of Mastodon Creek, but the evidence of mineralizati is not so strong. The gravels vary from 12 feet in thickness ne the mouth to 4 or 5 feet near the head. The pay streak varies fr 2 to 6 feet in thickness and 20 to 40 feet in width. The grade of t stream is about 150 to 200 feet to the mile. In 1906 mining w carried on in a small way at half a dozen localities.

HARRISON CREEK.

Gold was found on Squaw Gulch, a tributary of Harrison Creek, as early as 1894, and considerable work was done on the main stream up to 1896. As no high values were found, Harrison Creek was nearly abandoned for the richer placers which promised better returns. It is only within the last two years that the problem of working these relatively low grade deposits has been seriously considered.

The creek has two forks called North and South, on both of which gold has been found, but only the former is now being developed. One of the first discoveries of gold in the basin was at Pitkas Bar, at the junction of the two forks.

The writer visited only the upper 4 miles of North Fork. Here the valley floor is 200 to 300 yards wide, with flat bottom and steep slope on the south side. On the north the valley rises more gently and is deeply covered with talus. There are no excavations in this slope, and while no topographic evidence of benches was noted, it seems not impossible that they may exist beneath the slide material. Farther downstream the valley gradually contracts and is said to narrow down to a steep-walled canyon before it joins South Fork. The valley of South Fork is somewhat broader and appears to be more symmetrical. From the junction of the forks the valley continues to broaden until it merges with the Birch Creek valley 12 miles below.

The bed rock on North Fork is probably chiefly quartz-mica schist, but the occurrence of some granite pebbles in the alluvium indicates the presence of that rock within the basin. The writer saw very few bed-rock exposures, but the character of the alluvium indicates that the schists are cut by numerous quartz veins, many of which are stained with iron, indicating mineralization. A slab of schist cut by a gold-bearing quartz vein found near the forks has already been described.[a]

Just above the canyon the bed rock is said to be 20 feet below the surface. From 6 to 7 miles above, near Discovery claim, the writer observed a depth of 8 to 9 feet to bed rock on the north side of the valley and near the center, but only 3 or 4 feet near the south wall. A mile or more upstream the bed rock was found to be 8 to 12 feet below the alluvial floor. In this part of the valley the grade of the stream is probably about 75 to 100 feet to the mile, and that of the bed-rock floor is approximately the same. Although no accurate data are available, the reconnaissance maps indicate about the same grade throughout this basin. Naturally the grade decreases near the mouth and in the canyon it is probably much steeper.

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[a] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 353–354.

The alluvial floor of the valley varies in width, but is about 300 feet wide at Discovery claim, and probably this is not far from an average for the two forks. Below the forks, as has been indicated, the valley is much wider. Well-rounded gravels characterize the alluvial deposits so far as seen by the writer. Bowlders of more than 2 feet diameter are uncommon, though some of 3 feet were observed. Much the greater part of the material is schist, with some quartz and a little granite. The gravels are well stratified, are loose, and so far as known are not frozen. It is this fact which has prevented the creek being thoroughly prospected, because the water flows in the gravels throughout the year.

There is little turf or muck on the gravels, and the whole section is in most places made up largely of sand and gravel. The bed rock is usually weathered and is broken by seams of clay, a secondary product, but so far as seen by the writer there is no well-defined stratum on the bed rock at the base of the gravels.

The gravels of both forks are known to be more or less auriferous. At a number of localities some gold has been mined by pick and shove methods, but the values so far as determined are not high enough tc make this a paying proposition. It is reported that as high as $5 a day has been made on this creek. It appears that the values ar rather evenly distributed, both horizontally and vertically. Ther is, however, a marked concentration in the lower 3 to 5 feet of th gravels, and much of the weathered schist carries gold to a depth o 1 to 2 feet. The gold is fine, flaky, and bright colored. The larges nugget reported, with a value of $4, was found on the upper part o the creek. There has not been sufficient prospecting to determin the value of any considerable body of gravel. While 5, 10, and 3 cent pans are reported from bed rock, these, of course, can not b considered as average values. Near the Discovery claim thirtee pans taken from gravel near bed rock are said to have yielded abou $1 worth of gold. Considerable garnet and pyrite occur with th concentrates.

At the time of the writer's visit only two groups of claims wer being developed. In the lower group, embracing several claims nea Discovery, a dam had been put in, with a view of ground sluicing an thus concentrating the values, which are subsequently to be shovel into sluice boxes. A small hydraulic plant has been established o another group of claims, embracing No. 3 to No. 17 above. Th gravels here are 8 to 12 feet thick, and the tailings are handled by small elevator. Water is brought from the creek above through flume 2,700 feet long under a head of 100 feet. This plant w erected in the fall of 1905, and was run for a short time in the fa and again in the early summer of 1906. At the time of the writer

isit in August the dry weather had caused a shortage of water, and he mine was not in operation.

Harrison Creek, with its thawed gravels and dissemination of values, vould seem to be worthy of investigation by those looking for ground o be mined by steam shovels or dredges. The bed rock, so far as mown, is soft and could be taken up by a dredge. Bowlders appear o be absent and the gravels are of a fairly uniform size. As it would equire 3 or 4 feet of water to float a dredge it might be necessary to ise steam shovels, which would considerably enhance the cost of nstallation and operation.

EAGLE CREEK.

Gold was discovered on Eagle Creek as early as 1895, but the wave f Klondike excitement, which carried many miners out of the ountry, retarded its development for several years. Since 1901 nuch profitable mining has been done on this stream.

Eagle Creek has two forks. The northern, called Miller Fork, does iot appear to carry values, but on the southern, called Mastodon Fork, placers have been found. The main stream has a gravel-loored flood plain 100 to 400 yards wide, but the tributaries flow hrough V-shaped gulches. The bed rock appears to be chiefly chist, with an abundance of quartz.

The alluvium varies from 8 to 20 feet in thickness. Of this 5 to 15 eet is muck. The gravels are subangular, but are fairly well stratiied and carry considerable clay. The bottom layer is usually made ip of 1 or 2 feet of sticky clay. The gravels are not frozen below the urface and water circulates through them all winter. The grade of he stream is reported to be about 100 feet to the mile. The pay treaks are 4 to 8 feet in thickness and vary from 30 to 80 feet in vidth. In some places parallel pay streaks have been mined. Much f the gold is coarse and it has a bright color, with higher value than iny other of the district.

Mining has been carried on for about 2 miles along the main creek ind half a mile up Mastodon Fork. A large part of it has been done y drifting in winter. Though the pay streaks are rich, the cost of perating, in view of the fact that all drifts had to be timbered, has een great. It is reported that during the winter of 1905–6 about 25 nen were at work on the creek. Recently a large group of claims ias been bought up on this creek, and it is reported that a company ontemplates working them by dredging methods.

OTHER CREEKS.

Besides those described above gold has been found on a number of ther creeks, which have yielded very little. None of these were visited by the writer except Twelvemile Creek, where no values have

been found. On this stream the bed rock is made up of a slabby quartzite, together with schists. Twelvemile Creek has a broad flood plain, but nothing is known of the depth of gravels, though they do not appear to be deep. Other streams in this part of the Birch Creek basin are said to carry auriferous gravels. A little mining has been done on Porcupine Creek, a tributary of Crooked Creek near the mouth of Miller Creek. The valley of the stream is wide and the gold in the gravels appears to be much disseminated. The gravels are said to be 12 to 15 feet thick. Some excitement was caused during 1906 by the discovery of gold on Portage Creek, a tributary of Medicine Lake, in the southeastern part of the Birch Creek basin. Though about $200 worth of gold was said to have been taken out of one claim, further prospecting failed to reveal any values.

At various times gold has been reported in the Preacher and Beaver Creek basins, but the presence of values has never been established. These basins appear to lie outside of the gold-bearing area, though details in regard to the geology are meager.

CREEKS TRIBUTARY TO YUKON RIVER.

GENERAL GEOLOGIC FEATURES.

The influx of prospectors in 1898, following the discovery of the Klondike, led to considerable prospecting along the streams tributary to the Yukon between the boundary and Circle. So far as known no placers have ever been found in the streams of this region entering the Yukon from the north. Mission and Seventymile creeks are referred to on page 38, and the present discussion will be confined to Washington, Fourth of July, and Woodchopper creeks, together with some smaller streams.

So far as known to the writer the gold that occurs on these stream is from a different formation than that found in the Birch Creel basin, and in at least one place it has its source in a conglomerate Therefore the character and extent of the deposits are probabl different from those of the placers above described. It must b admitted, however, that the evidence at hand is too incomplete t permit definite assertion in regard to the bed-rock geology of much c this belt.

The rocks exposed along the Yukon between Eagle and Circle d not anywhere include any of the older schists, such as are associate with the Birch Creek placers. In fact, over much of this belt tl formations are slightly altered limestones, shales, slates, and coı glomerates, which do not bear evidence of mineralization and will nc attract the placer miner. Locally, however, some of these rocks a mineralized and contain more or less gold. Thus on Nugget Gulc

a tributary of Washington Creek, slates of Cretaceous age are found which are permeated with quartz veins, some of which must yield gold, as the associated alluvium is auriferous. The writer was not able to study this locality, but it appears that the coarse gold occurs in small patches on the bed rock. This occurrence, though probably of small commercial import, has a far-reaching significance, as it indicates that there has been an intrusion of mineralized veins since these younger rocks were deposited. The writer is, however, of the opinion that this mineralization is not general enough to encourage the search for placers where these Cretaceous slates form the country rock.

The occurrence of gold in the conglomerate has an entirely different significance. There appears to be a fairly well defined belt of conglomerate running parallel to the Yukon from Seventymile Creek to Birch Creek, near the big bend. Both in the Seventymile basin and on Woodchopper Creek placers have been found which must have derived their gold from this rock. Therefore the conglomerate must, in part at least, be auriferous.

This conglomerate was probably laid down in Tertiary time, after the mineralization of the older rocks, and its gold content is comparable to that of the present placers. Such auriferous conglomerates have long been known in the Yukon region, having first been noted by Spurr,[a] who termed them "fossil placers." There is no evidence that the conglomerate itself carries sufficient value to pay for milling, though this is not impossible. The fact that the associated placers are only of moderate richness argues against any considerable values being found in the parent rock.

Much of the conglomerate is only loosely consolidated and weathers so readily that it is easily mistaken for high bench gravel. As a result prospectors sometimes assume that it marks an old river channel and expect to find very rich leads. Though it is not impossible that the conglomerate represents the deposit of an old watercourse, it by no means follows that such a deposit would be any richer than the placers of the present stream. The term "old channel" has a very alluring sound to those who are familiar with the occurrence of gold in California. Even if this conglomerate should locally be found rich in gold, only such parts of it as are decomposed could be mined by placer methods. Therefore the gold in it, except where it has served to enrich present streams, has now no commercial significance.

The double concentration which must have taken place while the gold of these placers passed from its original source in the bed rock through the conglomerate and into the alluvium of the present streams is favorable to the formation of rich placers, yet none have

[a] Spurr, J. E., Geology of the Yukon gold belt, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 365-366.

been found. This is probably due in part to the fact that the conglomerate itself carries no great values and in part to the fact that much of the conglomerate has not been affected by erosion and therefore the gold in it has not been re-sorted.

The placers to be described here have little in common, and therefore few general statements can be made. So far as they have been opened up, neither high values nor extensive pay streaks have been found. It is by no means impossible that somewhere in the conglomerate belt erosion has found a rich layer in the conglomerate and that more valuable placers have been formed than any thus far discovered.

These placers have the advantage of being more accessible than most of those in the Yukon basin. Most of them are not over 10 or 15 miles from steamboat transportation on the Yukon. As they lie in the lower parts of the plains of considerable streams, they could probably be reached with water carried in ditches, provided there is a sufficient body of auriferous gravel to warrant the outlay.

NOTES ON DEVELOPMENT.

FOURTH OF JULY CREEK.

Fourth of July Creek was not studied by the writer. The best information obtainable indicates that the bed rock is limestone and slate with some conglomerate. The gold is said to have its source in the conglomerate. The deposits are reported to be from 10 to 20 feet thick, 6 to 15 feet being made up of muck and 4 to 5 feet of gravel, of which 3 feet is said to carry values. The gold is flat, fine, and bright colored. The largest nugget was valued at $2.25. As a rule the bed rock is deeply weathered. One bench is reported to carry values, but the relations are obscured by the abundance of slide matter.

A trail 10 to 12 miles long leads from Nation, on the Yukon at the mouth of Fourth of July Creek, to these placers. Though many claims have been staked and considerable prospecting done, the ground thus far productive is limited to a small group of claims. The total output since the discovery in 1898 is estimated at between $25,000 and $30,000 in value. Plans are said to be under foot looking toward larger operations in this field. It is reported that half a dozen men were at work here in 1906.

WASHINGTON CREEK.

GOLD.

Washington Creek flows through a northward-trending valley, whose floor is from half a mile to a mile in width. The bed rock for the lower 3 miles of the creek is black slate or shale of Cretaceous age.[a]

[a] Collier, A. J., Coal resources of the Yukon: Bull. U. S. Geol. Survey No. 218, 1903, pp. 28-32.

Farther upstream the creek cuts a greenstone and chert formation, probably of Devonian age, and 10 miles from the Yukon it crosses another belt of Cretaceous slate, which forms the bed rock in Nugget Gulch, a small southerly tributary. These rocks are succeeded to the south by a broad belt made up of a Tertiary conglomerate, sandstone, and shale series, which contains some lignitic coal seams. This belt of coal-bearing rocks has a width of at least 10 miles. Still higher up the valley older rocks are said to occur again.

Placer gold has been found at two localities in the Washington Creek basin—(1) in Nugget Gulch, about 9 miles from the Yukon, and (2) on Surprise and Eagle creeks, about 10 miles above. The placers on Nugget Creek consist of very much localized accumulations of coarse gold on bed rock. Values are so irregularly distributed that it is questionable whether they can be mined at a profit. The gold appears to have its source in the Cretaceous slates, and it is worthy of consideration at least whether the mineralization of the bed rock is not sufficiently localized to pay the cost of extraction. The upper locality was not visited by the writer, but from the best accounts the gold here appears to be derived from a conglomerate. The value of the total production of Washington Creek does not exceed a few thousand dollars.

COAL.

Washington Creek has been the scene of some ill-advised attempts at coal mining. Though there is considerable lignite in the basin, much of the money spent in development has been wasted on experiments in transportation rather than in testing the seams as to extent and quality. The coal openings are from 10 to 14 miles up the creek, and as the seams exposed appear to be of no better quality or greater thickness than others which lie much closer to the Yukon, the outlook for profitable exploitation is not hopeful. The seam examined by the writer, about 14 miles from the river, occurs in friable sandstone and shales, striking about east and west and dipping 30° N., and showed the following section. The exposure is on the north side of the valley, about 40 feet above the stream level.

Section of coal seam on Washington Creek.

	Ft.	in.
Roof, soft blue-gray shale.		
Shaly lignitic coal	2	6
Clay	0	2
Shaly lignitic coal	2	0
Bone parting	0	2
Good lignitic coal	1	0
Clay	0	5
Good lignite	1	0
Clay shale	0	1
Impure coal (lignite)	0	3

	Ft.	in.
Clay shale	0	2
Coal (lignite)	1	4
Clay shale	0	2
Lignitic coal with some partings	2	0
Clay shale	0	3
Impure lignitic coal	1	0
Good coal (lignite)	0	1
Clay shale	4	0
Good lignitic coal with bone partings	1	4
Clay shale with some bone partings	4	0
Covered, but probably no coal.		

The coal carries considerable sulphur. On burning it produces many clinkers. The ash has a reddish tinge. The following is an analysis of a sample taken from this same district a little lower down the creek:

Analysis of coal from Washington Creek.[a]

Water	13.48
Volatile combustible matter	43.74
Fixed carbon	39.68
Ash	3.10
	100.00
Sulphur	.24

The remarkably low percentage of ash suggests that this sample was taken from one of the minor seams and was not an average of the entire section exposed. Such a grade of coal could probably only be secured by hand picking after mining.

During 1905 and 1906 a company attempted to establish a winter transportation system to the Yukon by the use of a 100-horsepower traction engine, which was expected to haul five sleds, each of 10 tons capacity. While such a scheme might be feasible with a good road-bed, it proved entirely impracticable without one. This plan involves the storage of the coal hauled in winter for consumption during the summer months—a doubtful experiment, because the lignite slacks readily after being exposed to the air.

In spite of the adverse conditions of mining and low grade of coals in this field, it shares with other fields of the Yukon a prospective value. There can be no question that with the present increase in the demand for fuel and the rapid destruction of the forests the time is not far distant when the Yukon lignites will play an important part in the commercial development of the inland placer districts.

COAL CREEK.

Coal Creek, together with its tributaries, Sam and Colorado creeks, which have yielded a little placer gold, was not visited by the writer, but to judge by the juxtaposition to Woodchopper Creek, it appears

[a] Collier, A. J., Coal resources of the Yukon: Bull. U. S. Geol. Survey No. 218, 1903, p. 31.

probable that the conditions of occurrence of the placers are about the same. Apparently, however, from the reported discovery of a galena-bearing quartz vein on Colorado Creek, all of the basin is not underlain by conglomerate. It is not known to the writer whether this vein carries values or what its dimensions are.

Three or four claims are said to have been worked in this basin during 1906. Most of the gold is said to have been taken from bar diggings in the main creek.

WOODCHOPPER AND MINERAL CREEKS.

Woodchopper Creek, which is about 12 miles long, enters the Yukon from the west, about 30 miles above Circle. Its flood plain is about half a mile in width, and the alluvium is probably 8 to 15 feet deep. Five miles from the Yukon, Mineral Creek, the scene of some placer mining, joins Woodchopper Creek from the south. The floor of the Mineral Creek valley is 100 to 150 wide, and the slopes are broken by benches. Woodchopper Creek has a gradient of about 100 feet to the mile. Remnants of benches are to be seen along the creek, the highest of these being marked by the ridge on the northwest side, which is flat and slopes toward the Yukon.

In the lower mile of Woodchopper Creek only massive greenstones were observed. Above these is a belt of black slate and limestones about a mile wide that continues nearly to the mouth of Mineral Creek, where it is succeeded by friable conglomerates in a belt said to be several miles wide. Chert and quartz pebbles dominate in the conglomerate, which is only imperfectly consolidated and outcrops in few places. This fact often leads to its being mistaken for bench gravel by the prospector.

So far as known the gold-bearing alluvium is confined to those creeks that cut the conglomerate, which, therefore, appears to be the source of the gold. Mineral Creek and its tributary, Alice Gulch, are the only streams which have thus far been found to be productive. Prospects are reported from Grouse and Iron creeks.

At the mouth of Mineral Creek the alluvial floor of the valley is about 75 yards wide, but narrows upstream. A mile upstream, at the mouth of Alice Gulch, it broadens out again into a basin about 75 yards wide. On the south wall of Mineral Gulch three well-defined benches were observed, having altitudes of about 20, 150, and 250 feet above the creek.

Muck is encountered on some claims to a depth of 30 feet; the gravels underneath vary in thickness from 2 to 5 feet and are made up chiefly of well-rounded quartz and chert pebbles. The pay streak lies in parallel channels 12 to 14 feet wide, as many as three of these channels having been found in a width of 80 feet. The pay streak under present systems of mining is from 1½ to 4 feet in thickness.

A varying amount of bed rock is taken up, depending on its looseness. Apparently gold occurs in bed rock beyond the depth to which it can be profitably extracted. The bed rock appears to be chiefly conglomerate, but in some places a plastic clay which may be a weathered shale interbedded with the conglomerate has been encountered. Prospectors report that the values are found in the conglomerate but appear to be absent in the clay. The conglomerate bed rock is invariably iron stained, where found under the placers. Gold has been found in the lower benches of the creek, but the higher benches have not been prospected.

The gold in the creek bed is usually bright colored, but that of the benches is dark. Most of the gold is coarse, the largest nugget having a value of $30. The value of the gold as reported by the miners is $19.09 to $19.30 per ounce, which would make it the highest of all found in the Yukon province. Values of 5 to 50 cents to the pan on bed rock are reported, but there are no data available for the average tenor of the pay streak.

Though Mineral Creek was staked as early as 1898, actual mining did not begin until several years later. In 1906 eighteen men were engaged in mining on this creek and more or less work was done on seven claims. Most of the work was by "shoveling in" methods, but one small hydraulic plant was used for stripping and three steam hoists were operated. Most of the mining was done in winter with the aid of steam points. The total production for 1906 is estimated to have been $18,000, of which four-fifths was taken out in winter.

THE BONNIFIELD AND KANTISHNA REGIONS.

By L. M. Prindle.

INTRODUCTION.

The northern foothills of the Alaska Range have been widely traversed by prospectors since the establishment of Fairbanks as a permanent supply point. In 1903 gold-placer mining commenced in the Bonnifield country, about 60 miles south of Fairbanks, and during 1906 the Kantishna region, about 150 miles southwest of Fairbanks and 30 miles north of Mount McKinley, was an area of considerable activity. These regions had produced, respectively, about $30,000 and $175,000 in placer gold. The writer and C. S. Blair, field assistant, were detailed to investigate the placers and also the deposits of lignitic coal of Cantwell River, which were visited by the Brooks party in 1902.

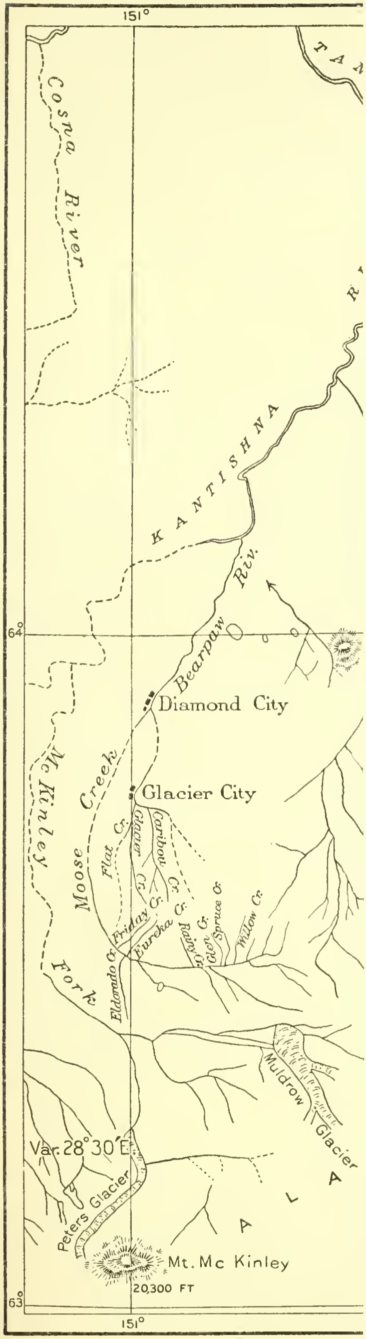
The sketch map (Pl. IV), with the foot traverses of the party in the two regions added to the topographic map made by the Brooks party in 1902, shows the geographic relations. The two most prominent geographic features of the entire area are the Alaska Range and the Tanana Flats.

The Alaska Range in this part of Alaska trends round from the northeast toward the east and is composed of lofty alpine ridges, surmounted here and there by beautiful peaks. Minor ridges flank the main range on the north and their outer members descend with more or less abruptness to the level of the Tanana Flats. All the drainage is to the Tanana. The main drainage lines are northward, transverse to the ridges. Many of the upper valleys are gorged with glaciers and the lower valleys are a succession of narrow canyons interrupted by east-west valleys parallel to the ridges.

The Tanana Flats extend northward from the base of the foothills to Tanana River. They have a width in the area under consideration of about 30 miles. They widen rapidly toward the west, as the river flows northwest and the mountains recede to the southwest, and form an impressive foreground to the mountains. The flats absorb small streams from the foothills and the surface is drained by swampy creeks, which cross them irregularly. The larger streams, a

few miles after leaving the hills, meander sluggishly in no well-defined valleys and enter the Tanana with sloughlike inconspicuity. The surface is sparsely timbered with small spruce, tamarack, birch, and aspen, with a larger growth near the major streams and along the base of the foothills. Swampy areas flecked with lakes are interspersed with patches of birch where the ground is bare and dry, and the traveling therefore fairly good. Feed is good along the water-courses but during the long hot days of summer there is scant relief for the pack animals from the horseflies and mosquitoes, which render an otherwise friendly area a place of almost constant torment.

The bed rock of the Bonnifield and Kantishna regions includes highly metamorphosed ancient rocks and loosely consolidated deposits of comparatively recent origin. The most common distinction made by the miners is that between hard and soft bed rock, and this distinction is warranted by the conditions. The ridges are formed for the most part of metamorphic schists and igneous rocks; the intervening longitudinal valleys, of deposits in the main unconsolidated but older than those of the present streams. The most important fact from an economic view point is the distinction between the two groups of hard and soft bed rock. The hard bed rock from south to north includes a belt of highly metamorphosed schists, predominantly quartzitic schists with a small amount of interbedded crystalline limestone, and some carbonaceous schists; a belt of black slates with quartzite and cherty beds; and a belt of metamorphosed porphyritic feldspathic rocks. The belt of quartzite schists forms most of the bed rock in the Kantishna region, crosses Cantwell River just south of Healy Creek and extends northeastward to the south of the Bonnifield region; the slates occur in the high ridges at the head of the Totatlanika and the porphyritic feldspathic schists form the several ridges to the north. These porphyritic schists occupy large areas in the northern foothills of the Alaska Range. They were observed throughout the area between Cantwell and Wood rivers. To the south they are interrelated with the black slates containing quartzite beds that succeed the quartzite schists. To the north they form the outermost ridges overlooking the Tanana Flats. Throughout this area are several prominent east-west ridges of these rocks rising 1,500 to 2,000 feet above the valleys that separate them. The color ranges from dark-gray to white. The prevailing tone is whitish, from the weathering of the large amount of feldspar that the rock contains, and much kaolinic material has been contributed by this rock to the deposits that occupy large areas in the longitudinal valleys between the ridges. The rock ranges in character from a coarsely porphyritic sericitic variety with feldspars 4 dm. or more in diameter to a fine, evenly grained white or gray sericite schist with no grains visible to the eye. These rocks are of igneous origin


151°
Cosna River
KANTISHNA
Bearpaw Riv.
Diamond City
Glacier City
Moose Creek
McKinley Fork
Flat Cr.
Glacier Cr.
Caribou Cr.
Friday Cr.
Eureka Cr.
Rainy Cr.
Glen Cr.
Spruce Cr.
Willow Cr.
Eldorado Cr.
Muldrow Glacier
Peters Glacier
Var. 28°30' E.
Mt. McKinley
20,300 FT
64°
63°
151°

SKETCH

SKETCH MAP OF BONNIFIELD AND KANTISHNA REGIONS.

and comprise highly metamorphosed rhyolitic rocks with probably some associated tuffs.

The soft bed rock includes thick beds of slightly consolidated sands, clays, fine gravels, and many beds of lignite, all overlain by thick deposits of gravel. Some of these deposits, at least, are of Tertiary age, and a more detailed description of them will be found in the section on the coal deposits (pp. 221–226).

BONNIFIELD PLACER REGION.

GENERAL DESCRIPTION.

The region known as the "Bonnifield country" is named for John E. Bonnifield, who was one of the first men to locate in this part of Alaska. The name referred originally to the region immediately west of Wood River, but as prospectors explored valleys farther west the name came to be used in a broader sense, and for the purposes of this report includes all areas of placer mining between Wood River and the Cantwell, 50 miles farther west.

The region is difficult of access in summer. The waterways are not easily navigable, even for small boats, yet supplies are sometimes brought in them about 40 miles upstream to points a dozen miles or more from the hills, whence they are transported overland by man or horse power about 20 miles to the creeks where they are to be used. Pack trains are occasionally taken over the flats along the west side of Wood River, but this method is expensive. Most of the supplies are transported during the winter, when streams afford good traveling for dog or horse sleds and the time consumed from Fairbanks to the creeks where mining is in progress is but a few days.

The region is delimited on the south about 20 miles south of the flats by prominent eastward-trending ridges which overlook it. The area between these ridges and the flats contains several ridges approximately parallel, with altitudes of 4,000 feet and intervening spaces a few miles in width at a level 2,000 feet below that of the ridges. Isolated prominences like Jumbo Dome form important landmarks and the area is one of diversity.

THE CREEKS.

The most striking characteristic of the drainage and one that finds explanation in the different conditions that once prevailed is the fact that the streams in general have cut canyons in ridge after ridge in their northward progress toward the flats. These canyons are for the most part narrow, and talus from the overtowering cliffs obstructs the streams. The intervening parts of the valleys are in general open, and gravel plains up to 1,000 feet or more in width have been developed.

The gravels include angular bowlders from the hard bed rock, finer material of the same nature, and a large proportion of well-washed gravels, in the main rather fine, which have been derived from the unconsolidated deposits that occupy large areas in the longitudinal valleys.

The creeks on which most work has been done are Totatlanika with its tributary Homestake; Grubstake, Roosevelt, and Hearst creeks, tributaries of the Tatlanika; and Gold King Creek, which flows independently out of the hills into the flats.

TOTATLANIKA CREEK.

Totatlanika Creek is comparable in size to streams of the Yukon-Tanana country like the Chatanika. It is formed by the union of several tributaries which originate in a high schist ridge to the south. It flows northward toward the flats, cutting canyons in several ridges of the igneous schist, and has developed in the intervening spaces tributaries that drain large areas in which the hard rocks are largely covered with coal-bearing deposits.

Mining was being done at scattered localities on the main creek along a distance of about 6 miles and on Homestake Creek, a small tributary. The conditions on the main creeks at all the localities are similar. The stream flat attains a width in the more open parts of the valley of several hundred feet, and the grade of the valley is approximately 100 feet to the mile. The quantity of water varies greatly. At ordinary stages on a rough estimate there are perhaps a dozen sluice heads available, and for the most successful working, by the methods employed, a low stage of water is desirable. The gravel bars at low water are mostly bare, and it is there and in the stream bed that the mining is being done. The bed rock includes hard, blocky porphyritic feldspathic schist with some associated carbonaceous schist and abundant quartz veins. A belt of andesitic rocks crosses above the mouth of Homestake Creek. The gravels are derived from these varieties of bed rock and from the unconsolidated coal-bearing deposits, which supply many vein-quartz and chert pebbles, pieces of lignitic coal, and a few large bowlders of the granite and greenstone that occur in the uppermost beds of these deposits. The thickness of the stream gravels where work is being done ranges from 3 to 6 feet.

The gold is found in most places scattered through the gravels, but in others is confined to the surface of the bed rock, and where this is blocky is generally found to a depth of 3 feet or more within it. The gold is mainly flat and most of the pieces are less than a quarter inch in diameter. Occasionally pieces are found worth 25 cents, and a $2 piece was the largest noted. It is all well worn. Pay has been found over widths of 50 to 100 feet, with values up to 1½ ounces per day to

the man, but too little work has been done to give definite information regarding the average dimensions, values, or persistence of the pay streak.

Mining is done by open cuts in combination with wing dams. The ground is for the most part free from frost, and the only trouble from this source has been experienced in constructing bed-rock drains. Wing dams are used to deflect the water from the ground that is being worked, and water for sluicing is carried from the dam a distance of a few hundred feet to the sluice boxes. These are given a grade preferably of 9 inches to the box. There is but little sediment in the gravels and no dump boxes are used.

The timber available for sluice-box lumber in this part of the valley is limited, and lumber is packed 5 to 25 miles from the lower canyon in the winter. About a dozen men were working on the creek during the summer of 1906.

HOMESTAKE CREEK.

Homestake Creek is a small stream, about 4 miles long, which enters Totatlanika Creek in the uppermost canyon. The valley consists of two parts of different character. The upper part is open and flat—hardly more than a depression in an undulating, well-nigh timberless area several miles wide—that extends east and west between the ridges. The lower part is a deep canyon with vertical walls of andesite that crowd the stream to a narrow, crooked course and burden it with great fragments. The grade of the upper valley is approximately 100 feet to the mile; that through the canyon is over 200 feet to the mile. The amount of water carried by the stream is, during a dry season, insufficient for mining purposes. The bed rock of the upper valley is composed of unconsolidated clay and sand of the coal-bearing formation; that of the lower valley is the igneous rock of the canyon.

Most of the mining has been done at the upper end of the canyon and in the open part of the valley half a mile farther upstream. The deposits that are worked range from 2 to 6 feet thick. Gold has been found in 2 to 3 feet of gravel, and part of it is coarser than that of Totatlanika Creek, one piece worth $15 having been found. All of the gold apparently is well worn. The stream heads in gravels and above the canyon has not yet cut down to hard bed rock, and it would seem that the gold has been derived from the gravels.

There are but few trees in the upper valley. Sluice-box lumber and even firewood are packed from the main stream. Some of the ground prospects well, but so little work had been done that the possibilities of the creek were not definitely known. Unlike those on the main stream, successful operations on Homestake Creek are dependent on abundant rainfall.

TATLANIKA DRAINAGE.

About 10 miles east of Totatlanika Creek is the Tatlanika, formed by the union of Sheep and Last Chance creeks. This is a somewhat larger stream and has developed for itself in the section of the valley under consideration a gravel plain several hundred feet wide, with a grade of about 90 feet to the mile. A finely preserved bench 40 feet high and half a mile or more wide limits the stream on the west, and 3 miles to the west high gravel hills separate the Tatlanika drainage from the headwaters of Buzzard Creek; on the east are blunt terminations of low, broad ridges that separate the small tributaries entering from that side—Grubstake, Roosevelt, and Hearst creeks, on which most of the mining is being done. These enter in the downstream order given, the mouths being separated by distances of 3 miles and 1 mile, respectively. The creeks are similar in size and character, and gold occurs on all of them under about the same conditions and with apparently the same origin. The Tatlanika in this area has not yet cut down to hard bed rock and these minor streams have cut narrow valleys for themselves in the unconsolidated gravels, clays, and sands of the coal-bearing deposits. Grubstake Creek heads along the contact of the schistose bed rock and the soft deposits and is the only one of the three that has the hard bed rock within its drainage basin.

GRUBSTAKE CREEK.

Mining on Grubstake Creek is confined to a mile of the lower valley. The stream is 200 to 300 feet below the steep inclosing slopes of soft material and the stream flat is 150 to 300 feet wide. The grade is approximately 100 feet to the mile. At the lowest stage the creek carries approximately a sluice head of water. The bed rock is sticky clay, sand, and coal, all three distinct from the stream deposits. The thickness of the gravels that are being mined ranges from a few inches to 6 feet. These gravels include both fine and coarse material, with a small proportion of bowlders. They are made up of schist, vitreous quartzite, compact conglomerate composed largely of chert pebbles vein quartz, chert, granite, and diabase; the amount of sediment in them is small.

Gold is found scattered through about 2 feet of gravel or confined mostly to the surface of the clay bed rock. The pay streak has a width of 25 to 75 feet, but outside of 25 feet is reported to be patchy The coarsest piece found was worth $1.43 and the gold is valued a $17.35 an ounce. The common variety is composed of small fla pieces, all well worn. Mining is done by open cuts. In some places a few feet of the top gravel are stripped off, but generally all the mate rial from surface to bed rock is shoveled in and the character of grave and bed rock is such that 6 cubic yards a day per man can be handled

The black sticky clay which forms the bed rock, after being cleared of the stream gravels, contains considerable gold which has settled into its surface or been trodden into it in the progress of the work, and experience has shown that the best way of saving this is to strip off a thin layer one-fourth inch or more thick, leave it in the sluice boxes over night with a small amount of water running over it, and in the morning stir it with a sluice fork. The loosened mass then easily yields up its gold. The boxes are set on a grade of 8 or 9 inches to the box. The lumber for mining purposes is brought from the lower canyon of the Tatlanika, a distance of 14 miles. Some mining was done during 1905 and half a dozen men were at work during 1906.

ROOSEVELT CREEK.

The lower part of the valley of Roosevelt Creek is rather open and is covered with a light growth of small spruce. The mining area is about 2½ miles above the mouth, where the valley is narrow. The bed rock is sticky clay and yellowish sand that belong to the coal-bearing formation. The stream gravels are similar to those of Grubstake Creek and are derived from the thick bed of gravels that caps the sands and clays. They are shallow and gold occurs in 1 to 1½ feet of grav l over a width of 20 to 60 feet. The gold is small, flat, and well worn, the coarsest piece found being worth about 45 cents. At the time the creek was visited there was insufficient water for sluicing. The gold has most probably been concentrated together with the stream gravels out of the thick gravel deposits in which the creek originates. A point to be emphasized is that the soft clays and sands which form the bed rock are just as truly bed rock to the stream gravels that overlie them and carry the gold as if they were hard rock. A thickness of several hundred feet of these unconsolidated deposits may overlie the hard bed rock and any attempt to sink through them to the solid formation would be not only a most difficult task, but, inasmuch as the only run of gold known overlies them, would be in all probability useless.

HEARST CREEK.

The conditions on Hearst Creek are similar to those on the other two streams. In the lower part of the valley the creek meanders deeply in a narrow canyon, exposing sections 100 feet thick of the unconsolidated light-colored, cross-bedded sands and fine gravels of the coal-bearing formation. These deposits in places have been benched and capped with stream gravels. The upper part of the valley is more open and the stream heads in the thick gravel beds that overlie the sands and clays. The only work that has been done is at a point about 2 miles above the mouth, where in 1905 a few thousand dollars were reported to have been mined. In 1906 this locality was being prospected.

GOLD KING CREEK.

Gold King Creek is about 8 miles east of the Tatlanika. The stream heads in hard bed rock and flows through a V-shaped valley sunk to a depth of 1,200 feet below the inclosing gravel ridges. Long, flat, tonguelike spurs extend from these ridges into the narrow stream flat. The grade is about 100 feet to the mile, and the quantity of water at the lowest stage is approximately three sluice heads. The bed rock at points where mining is in progress is clay. The gravels include the same varieties as are found on the other creeks, and the proportion of bowlders 3 feet or more in diameter is large. They lie scattered through the gravel and have acted as efficient riffles in retaining the gold. The thickness of the gravels that are being mined ranges from 4 to 8 feet. In some places gold is found in 4 to 5 feet of gravel; in others it is mostly near the clay bed rock. Generally about 2 feet of overburden are ground sluiced off and from 1½ to 4 feet shoveled into the boxes. The gold is flat; there are many pieces over one-fourth inch in diameter, and the coarsest piece was worth $1.25. This gold is said to assay $17.82 per ounce. Some of the ground is reported to yield about 1½ ounces to the shovel. All the work is done by open cuts, and the presence of so many bowlders retards the work. Shoveling in can begin in some seasons about the first of June. During the season of 1906, however, on account of the extent of glaciers in the creek work did not begin until June 20. The gold, like that of the other creeks, probably originates in the high gravels, and these are reported to carry prospects in many places far above the creek and even on the surface of the high, flat ridges. About a dozen men were working on the creek, and wages were $6 and board per day.

SUMMARY.

The creeks of the Bonnifield region may be divided into two classes—those that have, in a part of their valleys at least, cut into hard bed rock, and those that are still cutting their valleys entirely in unconsolidated deposits, including gravels, sands, clays, and coal beds. The greatest part of the gold has in all probability been derived from the thick gravels. The form of its occurrence in these thick deposits is unknown. It may be regularly distributed through them, it may be confined to some particular stratum in which it is spread broadly, or it may occur as a more or less clearly defined pay streak. The material of the gravels is all found in the ranges to the south. The gravels were deposited under conditions much different from those of the present time and are probably mixed in their upper part with some glacial material.

The only general test of the values that these gravels may contain thus far available is that afforded by the gold found in the gravels o

the present streams. Although fair pay has been found in places on some of the creeks, it would seem that if the high gravels carried noteworthy values the placers derived from them would be much richer than they have yet proved. All the work has been accomplished on a small scale under adverse conditions. Most of the mining is being done above the timber line. The work is hampered and in some places brought to a standstill by lack of water. The soft nature of the bed rock in some of the creeks means a tremendous amount of material that clogs the work and complicates the situation caused by lack of water. In general it may be said that the quantity of gold is not such as to overshadow the economic factors of water supply, character of bed rock, presence or absence of bowlders in the gravels, timber resources, and transportation, but that in every case these are the determining factors in the situation.

KANTISHNA PLACER REGION.

GENERAL DESCRIPTION.

The rich shallow diggings discovered in the Kantishna region in 1905 were found to be more local than at first supposed, and the results of 1906 were unequal to expectation. During the fall of 1905 there was much travel by steamer from Fairbanks. Passengers and freight were carried at $40 a piece and $50 a ton, respectively, and landed at Roosevelt, on McKinley River, or at Diamond, 60 miles above the mouth of the Bearpaw. The town of Glacier also was established 12 miles from Diamond, at the mouth of Glacier Creek, about midway between the steamer landing at Diamond and the placers of Glacier Creek. During the winter of 1905–6 there was much travel between all of these places and the creeks, and the winter trail from Fairbanks up Cantwell River to the road house at the crossing and thence overland was also used extensively. The month of February found many already on the back trail. During the summer of 1906 the town of Roosevelt, situated as it was remote from the creeks across an 18-mile stretch of swampy tundra, became practically deserted, and in the fall the many empty cabins of Glacier and Diamond testified with depressing emphasis to the decadence from the activities of the previous year.

The Kantishna placers, about 30 miles directly north of Mount McKinley, are in an outlying ridge somewhat apart from the main range and separated from it by high bare hills, which form the foreground to this portion of the range. This ridge trends northeast and southwest, and its most prominent summits have altitudes of 4,000 to 4,700 feet. To the southwest it abuts against the foothills; to the northwest it descends abruptly to the level of long, flat slopes that extend for miles from the base of the hills into the extensive flats of the Kantishna Valley.

The slopes are deeply furrowed by narrow V-shaped valleys. The drainage on the south runs into Moose Creek, a stream that heads far back in the foreground of the mountains, flows close along the southern base of the ridge in a finely benched open valley, and finally cuts a canyon through the ridge to flow northward to the Bearpaw. The streams that drain the northern slopes have long lower valleys limited on either side by the edges of low tonguelike spurs.

The material of the ridge is for the most part a highly metamorphosed and closely folded quartzitic schist, with garnetiferous quartz-mica schist, carbonaceous schist, a small amount of interbedded crystalline limestone, and much greenstone, part of which at least is intrusive. This formation is like that at the canyon of Cantwell River, south of Healy Creek, and is the same in character as that of the Fairbanks region. The occurrence of gold also and the associated minerals are the same for the most part as in the Fairbanks region. The formation has in general a northeasterly strike. The foreground of the mountains to the east is formed of hornblende granite and granite porphyry and some dikes of granite porphyry occur in the schists. Small areas of the coal-bearing rock occur in the region and coal from a fork of Moose Creek is utilized to some extent for blacksmithing purposes. The extension of the schist area to the southwest has not been determined. Topographically it terminates apparently at McKinley River; to the northeast it is probably continuous with the schists of the Cantwell Canyon. The rocks of the Alaska Range to the east are in general black slates partly altered by contact metamorphism, greenstones, intrusive granitic rocks, and volcanics.

THE CREEKS.

The creeks head in open V-shaped areas formed by the convergence of two or more small tributaries. The lower parts of the valleys are narrow canyons. Where these join the main valleys benching becomes prominent and their deposits merge into the tremendous body of gravels that has been spread far and wide from the Alaska Range. This material is for the most part easily distinguishable from the schistose gravels of the creeks.

The creeks where mining has been done are located on both sides of the ridge. Named from east to west on the south side of the ridge, round the west end and eastward along the northern slope, they are as follows: Spruce, Glen, Eureka, Friday, Glacier, and Caribou.

SPRUCE CREEK.

Spruce Creek flows its last mile in the valley of Moose Creek. Above this part of its course for about 1½ miles the valley is narrowly V-shaped and then near the head becomes more open. The grade in the narrow

part is about 350 feet to the mile, and the amount of water carried at ordinary stages is about two sluice heads. The lower valley has a considerable growth of spruce in a narrow belt near the stream. The bed rock observed is predominantly quartzitic schist, with some carbonaceous and green schists. The only point where mining was being done is about 2½ miles upstream, above timber line and about 700 feet above the level of Moose Creek. The gravels at this point are about 3 feet thick and comprise quartzitic schists with a small proportion of green schist, carbonaceous schist, crystalline limestone, and vein quartz. Pay is found over a width of about 12 feet. The gold occurs mostly on bed rock and to a depth of 2 feet within it. Much of the gold is coarse, and the largest piece found was valued at $6.40. Some of it is rough and has quartz attached, and there is no reason to doubt its local origin. Three men were working at this locality. Their sluice boxes were made of lumber packed from Glen Creek and were set on a 10-inch grade.

GLEN CREEK.

Glen Creek is somewhat larger than Spruce Creek and is more deeply cut below the spurs that rise nearly 1,000 feet above it on either side. From the forks to the mouth, a distance of 3 miles, there is a grade of about 500 feet. The gravels are similar to those of Spruce Creek, being predominantly quartzitic schist, and where work is being done they range from a few inches to about 3 feet in thickness. In some places gold is found through 2 feet of gravel and at others it is all on or within bed rock. The width over which pay is found ranges from 30 to 150 feet and values have been reported of $20 to $100 to the box length, or approximately a maximum value of 65 cents to the square foot of bed rock, but their distribution is irregular. Much of the gold is coarse; several $8 to $10 nuggets have been found, and the largest piece discovered weighed over 3 ounces. A few garnets are found associated with the gold. At the time of visit most of the miners had left for the season, and it was reported that only about seven men would winter on the creek.

EUREKA CREEK.

Eureka Creek proved to be the best producer of the region. It is a small creek only about 5 miles long, flows southwestward in a deeply cut valley, and enters Moose Creek just below the point where the latter has turned northward through the ridge. The valley of Moose Creek at this point is a flat several hundred feet wide, and the creek itself, a powerful stream, swings round to the east and is cutting laterally into the bed rock just at the point where Eureka Creek enters. The valley of Eureka Creek has a grade of about 235 feet to the mile, and the smallest quantity of water flowing during the season of 1906

was reported to be two sluice heads. The bed rock is principally quartzitic schist, with some associated carbonaceous schist and greenstones. Small basaltic dikes were observed in a few places cutting the schists. Throughout most of the valley the stream gravels are composed of material derived from the bed rock, but in the lower part of the creek these rather fine subangular schist gravels become mixed with material derived from the heavy Moose Creek wash that rests on a bench over 150 feet vertically above Eureka Creek. In the process of downward cutting through which the drainage system has passed these bench gravels, comprising bowlders of granodiorite, greenstone, hard conglomerate containing chert pebbles, and metamorphic slates, all of these being materials mostly unlike those characteristic of the Eureka Valley, but entirely similar to those of the Alaska Range, have become intimately mingled with the local deposits.

Mining has been confined for the most part to 2 miles of the valley immediately above the mouth. The thickness of the deposits that are being worked ranges from 1 to 5 feet and the width is in most places that of the stream gravels, which is rarely more than 100 feet and in some places less than 20 feet. The gold is mostly on bed rock or within it to depths of 1 to 3 feet, but all the gravel from surface to bed rock is generally shoveled into the boxes. The richest ground was in the first half mile above the mouth, where many nuggets were found, the two largest of which were worth \$186 and \$678. Nuggets were not confined to this part of the creek, however, and some worth as high as \$40 have been found 2 miles above the mouth. The nuggety gold is generally of a lighter color than the finer grade. The gold found in the upper part of the valley is mostly rough and gritty. Average assay values were reported ranging from \$15 to \$16 per ounce. The proportion of black sand accompanying the gold is small. Here and there pieces of stibnite occur in the gravels, and these have been derived, probably, like similar occurrences on Caribou Creek, from veins in the schists. The association in this respect is similar to that of the Fairbanks region.

The reason for the richness of the gravels near the mouth has often been a subject of inquiry and it might be supposed that a part of the gold at least was derived from the heavy Moose Creek bench gravels through which Eureka Creek has cut. So far as could be learned, however, these bench gravels are not known to carry payable values, and the explanation is rather to be found in the riffle efficiency of large bowlders in retaining gold that would otherwise be carried out from the smaller valley along with the finer wash. A decrease of grade of the smaller stream near the mouth may also be a factor.

All the gravels are worked by the open-cut method. Boxes are given grades ranging from 7 to 9 inches per box. There is but little

sediment in the gravels and no dump boxes were employed. The flats of Moose Creek opposite the mouth of Eureka Creek are covered with a light growth of small spruce and a few small spruce dot the steep slopes of the lower Eureka Valley, but lumber for mining purposes has to be brought from points 6 miles down the Moose Creek valley.

Gold was discovered on Eureka Creek in July, 1905. The richness of the gravels justified to a great degree the stampede that followed. The richest ground that has been discovered was mostly exhausted during July and August, 1906, when there were 50 or more miners on the creek. Wages during the busiest time of the season, when shifts were working night and day, were $1.25 per hour, paid in gold dust valued at $16 per ounce. There was a settlement of considerable size at that time on the flat of Moose Creek just above the mouth of Eureka Creek. A restaurant was in operation with rates for board alone of $4.50 per day, and there were small stores where supplies of various kinds were obtainable. About a dozen men were working in August, 1906. Various estimates of the output were reported, ranging from $150,000 to $160,000.

A small amount of work was done during the summer in the canyon of Moose Creek, about 5 miles below Eureka Creek, and some pay was reported.

FRIDAY CREEK.

Friday Creek is 2½ miles long and carries at the lowest stage about half a sluice head of water. The valley is cut to a depth of 1,500 feet below the inclosing ridges. The upper part where small streams unite is somewhat openly V-shaped; the lower part is very narrow and has a grade of over 400 feet to the mile.

Mining is confined to about a mile of the creek above the point where it emerges into the valley of Moose Creek. The bed rock includes quartzite schist, carbonaceous schist, greenstone, crystalline limestone, and dikes of granite porphyry. The gravels are formed mostly of these materials and are from 3 to 6 feet thick. Gold is found in 1½ to 2 feet of gravel and about the same thickness of bed rock. The gravels are in some places limited to the narrow space of 12 feet between the bed-rock walls; in others they reach 100 feet in width. Both nuggets and fine gold are found. The nuggets range in value up to $29. Many of them contain much quartz and are very rough, and some are rudely crystallized. Scattered pieces of galena several inches in diameter are found in the stream gravels, and one of these was assayed for the Survey and found to carry 184.76 ounces of silver and 0.20 ounce of gold to the ton. Only six men were working on the creek.

GLACIER CREEK.

It is about 8 miles round the base of the hills from Friday Creek t Glacier Creek. The latter is a larger stream than the other creek that have been described, heads against them, and after emergin from its deep V-shaped canyon flows for several miles between broad level-topped ridges before it joins the Bearpaw. Cabins were built a intervals along the entire length of the creek during the winter o 1905–6, but the area that up to the present time has proved most pro ductive is a section of the valley about a mile long where the creel emerges from the hills into the area of long gravel-covered ridges Near the end of the season of 1906 it was reported that pay was bein found also on Yellow Creek, a small tributary near the head.

Glacier Creek, although considerably smaller than Moose Creek, i a powerful stream, and there has been no lack of water for mining pur poses. The grade of the valley in the part that is being worked i approximately 130 feet to the mile. The bed rock observed com prised quartzite schists, greenstone schists, and garnetiferous mic schists, with abundant quartz seams and lenses. The gravels ar coarse and the proportion of bowlders is large. The thickness of th deposits in the working area ranges from 2 to 5 feet, and the width i places is 250 feet. The gold is mostly on bed rock. The creel meanders sharply at its point of emergence from the hills, and th best pay is reported to have been found just above the points of th meanders. Values have been found ranging from $75 to $200 to th box length, and the gold is reported to be worth $16.40 per ounce Many nuggets have been found, and the largest was valued at $365.

At the point where the stream leaves the hills there is a bench abou 75 feet above the creek, capped by 3 to 5 feet of gravel underlying 6 t 8 feet of muck. Gold occurs in about 18 inches of the gravel and i yellower and flatter than the creek gold. Several areas of the benc gravels were reported to prospect, but insufficient work had been don to determine their values definitely. All the work was done by ope cuts, and some of the lumber for sluice boxes was packed distances o 12 to 14 miles from Moose Creek. In the fall of 1906 there wer approximately twenty men on the creek.

CARIBOU CREEK.

Caribou Creek is somewhat larger than Glacier Creek, but in othe respects the conditions are similar. There is the same variety of be rock and deposits, but up to the present time no well-developed pa streak has been found. In the early part of the season considerabl work was done on Crevice Creek, a small tributary near the head The gold was found to be rough and coarse, the largest piece bein valued at $90. At the time Caribou Creek was visited by the Surve party but few men were working.

Stibnite (antimony sulphide) occurs in the wash of Caribou Creek, nd a ledge containing this mineral has been located a short distance bove the point where the creek emerges from the hills into the enched area of the lower valley. The creek forks at this locality, and n the southern fork, which has been named Last Chance, the ledge is xposed. The vein is about 4 feet thick, and the vein matter includes ssentially quartz and stibnite. The quartz is partly massive and artly in the form of small crystals up to an inch in length. The ntimony sulphide is in part a crystalline mass embedded in the spaces etween the quartz crystals and in part a bluish-black, very fine-rained massive variety. The ledge strikes northeastward and dips 5° N. The country rock is hornblende schist, to the structure of which the vein conforms. A short distance upstream the hornblende chist is structurally conformable to the quartzitic schist. A small mount of work was being done here in the hope that the ledge mate-ial would be found to carry values. Of three specimens from this ocality assayed for the Survey two contained silver at the rate of 4 nd 2.76 ounces to the ton and the latter carried in addition 0.12 unce of gold to the ton; the third specimen contained 0.12 ounce of old, but no silver. Too little work had been done to give definite nformation regarding the proportion of the antimony sulphide in the ein, but pieces of nearly solid ore up to a foot in diameter were btainable.

SUMMARY.

The Kantishna placers are in an area of crystalline schists. The gold-producing creeks head near each other. The bed rock of all the creeks comprises practically the same kinds of rock and the gravels are shallow. The bulk of the gold in every case has in all probability been derived from the valley in which it is found. The occurrence is not confined to any particular section of the valleys, but is such as to suggest a derivation from different points along them. The manner of its occurrence in the bed rock is indicated by the many pieces found in most intimate association with quartz, by a small flat nugget one-tenth of an inch thick attached to garnetiferous mica schist, and by the occurrence of silver- and gold-bearing galena and stibnite in the gravels of several creeks. Pieces of these sulphide ores a foot or more in diameter were observed in the gravels, and the fact that in one case high values in silver with some associated gold were carried by this material lends not only a qualitative interest to this occurrence but a quantitative one as well. The vein of stib-nite on Caribou Creek, although carrying in the material tested no high values in silver or gold, illustrates the form of occurrence, and its interest is enhanced from the fact that the metal antimony, which forms about 70 per cent of the mineral stibnite, is at present (1907)

in considerable demand. Regarding the question whether there sufficient high-grade silver ore or stibnite to pay for working, nothi definite can be said. It is probable that both the lead and antimo sulphides and the small amount of iron pyrites associated with the occur as small veins scattered through the schists. Although bo stibnite and galena resemble each other to some extent, the form has often been determined by miners through its character of fusi readily in the candle flame. The coarser varieties can also be d tinguished from galena by their lighter color and somewhat fibro texture. The coarser varieties of galena break into little cubes.

There is a great resemblance between the Kantishna and Fairban regions. The geologic environment and mineral associations a practically the same. The essential difference is apparently one physiographic development. The Kantishna region is in a youth stage. The valleys are narrow and have steep grades, and th deposits are consequently shallow and have undergone less shifti with the accompanying gravitative differentiation of the heavy co stituents to the vicinity of bed rock.

The bulk of the production has come from Eureka Creek and m of the remainder from Glacier Creek. The conditions on Eure Creek probably find an explanation in the fact that the heavy forei wash derived from the bench near the mouth, working in combinati with a decrease in grade, checked to a greater or less extent the remov of the gold that was being brought down the valley of Eureka Cre while the canyon was being cut, and thus brought about an enric ment at this particular point. There is the possibility, too, that t bench gravels contributed a part of the gold. It is noteworthy this connection that the richest ground on Glacier Creek is at t point where the valley emerges from the hills into the benched ar that surrounds their base.

There was no lack of water during the summer of 1906, but in dry season the small creeks would shrink below the economic lim The timber resources in the vicinity of the hills are scanty. The is some fair timber along parts of the valley of Moose Creek and t increases in quantity toward the mouth, but in general the localit where mining is done are above the limits of good timber, and lum has to be packed for several miles. The town sites of Glacier a Diamond were well timbered, and the valleys of the Bearpaw a Kantishna contain many small areas of fine spruce.

Steamer transportation during the summer of 1906 was ve irregular, and the accessibility of the placers to the points where it possible to land supplies from steamers is rendered difficult on accou of swampy areas that in places well-nigh block the approaches to t hills. Up to the present time but little attempt has been ma

construct summer trails, as most of the transportation between the reeks and the local supply points has been done in winter.

The auriferous gravels thus far discovered are adapted only for ummer work when sluicing can be done from about the 1st of June the early part of September, and the rich ground first discovered as been largely worked out. There is some ground still remaining hat contains fair pay, and about 50 men intended to remain during he winter of 1906–7 to prospect.

COAL DEPOSITS.

GENERAL DESCRIPTION.

Deposits containing lignite coal have a wide distribution in the orthern foothills of the Alaska Range, but the only section to be conidered here is that extending east from Cantwell River to Wood River, a distance of about 50 miles, and northward to the flats. The low spaces within this area between the east-west ridges of old metamorphic rocks are occupied by these deposits. They are for he most part but slightly consolidated, and have been so deeply ncised by the drainage systems that in places nearly complete secions are exposed. That the present areas are only a part of masses ormerly much larger in extent is shown by small isolated patches of hese deposits that lie slantingly on the upper slopes of ridges and by well-worn pebbles derived from them that lie scattered on the tops of the highest ridges, 1,500 to 2,000 feet above the occurrences of the valleys. These deposits have been folded, the flexures being for the most part broadly open, with dips of 30° to 35°, but locally closer, with resultant vertical dips attended in places by consolidation of the gravel beds to conglomerate; in addition, here and there parts of the deposits have been faulted.

The material comprises alternating beds of sands, clays, coal, and gravels that are divisible into three parts—an underlying white deposit composed of angular and some well-worn, subangular, fine quartz gravels, with a large admixture of kaolinic material where the bed rock is feldspathic, an intermediate member of yellowish cross-bedded sands and fine well-worn gravels, dark plastic clays, and coal beds, and an upper member composed almost entirely of gravels. The feldspathic schists produce by weathering a large amount of white clay and the quartz veins which in places in these rocks are very numerous furnish abundant quartz material, and these characteristics of the old bed rock have gone over into the basal members of the sediments. The transition from the decomposed products of the schists that still retain their structural position to the same materials in the overlying deposits is in some places strikingly exhibited. The

thickness of these underlying deposits was not determined, but or section was observed in which 100 feet of them was exposed. Th sands and clays of the intermediate member are naturally less cor spicuous than the underlying beds, but have in many places becom indurated by the burning of the coal beds and baked to a conspicuou red color. The overlying gravels at the localities where their relation to the underlying deposits were observed, whether in horizontal c tilted strata, were found to be structurally conformable. They ar characterized by a yellow color. They include both fine and coars material, are well worn and well rounded, and the predominant cor stituents are white quartz and chert of various colors, principall black. There is a considerable proportion of metamorphic rocks an many pebbles of compact chert conglomerate. In the upper part c the gravels, in strong contrast with their medium- to fine-graine material, are locally many bowlders of granitic rocks and diabase an a few well-rounded bowlders of dense chert and quartzite conglon erates. The greatest observed thickness of these deposits was approx mately 3,500 feet. The upper gravels constitute about half of th entire deposit.

Fossil leaves are observable nearly everywhere in the beds asso ciated with the coal, but except where these beds have been baked b the burning of the coal the fossils are poorly preserved. The age c the coal-bearing member has been determined as Kenai. The age c the gravels has not been determined, nor is it definitely known tha they are chronologically conformable with the underlying deposit but they have been folded at every point where folding was observe along with the underlying deposits. Where valleys have been exter sively developed in these deposits bench gravels have in many place been laid down on the truncated edges of the older deposits, and wher these older beds are horizontal the bench gravels are in apparent cor formity with them, obscuring the relationship. It is probable tha deposits of various ages since the Kenai, formed under varied cond tions of sedimentation, occur in this area and that the coarse materia in the uppermost part of the gravels owes its origin to glaciation.

Parts of the gravel members of these deposits are auriferous an have supplied the gold for the Bonnifield region. There is a marke resemblance between these coal-bearing deposits, with their thick bed of overlying gravels, and the Kenai beds of the Seventymile Cree area near Eagle, with their coal-bearing deposits and thick beds c conglomerate formed largely of the same kinds of material. Thes latter beds also, as was observed by Brooks in the Woodchoppe Creek area during 1906, are auriferous.

LOCAL OCCURRENCES.

The most prominent exposures of coal are on Healy Creek and Lignite or Hosanna Creek. These localities have been described by Brooks.[a] In 1906 a large part of the coal-bearing area on Healy Creek had been staked as coal claims.

Healy and Lignite creeks are about 5 miles apart. The valley of Healy Creek near its junction with the Cantwell is limited on the south by a high schist ridge. A similar ridge separates the valleys of Healy and Lignite creeks, but the schist part of this ridge terminates about 3 miles from the Cantwell and its continuation is composed of the thick body of gravels with the underlying coal deposits, which along the Cantwell becomes continuous with the deposits of Lignite Creek.

HEALY CREEK.

The deposits extend about 10 miles up Healy Creek, in places running parallel with the creek and in places crossing it. In the lower part of the valley they dip north from the schists, on which they rest unconformably, at angles ranging from 25° to 35°. Toward the upper limit of the deposit folding has been closer and there are vertical dips. The stream flat of Healy Creek is about 500 feet wide, and in parts of the valley coal beds form the banks for distances of a quarter of a mile or more close to the water. The thickness of these deposits from their base to the under surface of the overlying gravels, which are approximately 2,000 feet thick, is about 1,500 feet and the coal beds aggregate about 230 feet. The nature of the deposits and the relation to them of the coals are shown in the accompanying section of the deposits at a point about 2 miles above the mouth of the stream. The coal thicknesses were measured with the tape; the thicknesses of the intervening beds are in part only approximate. This section probably does not give the total thickness of coal, because some beds in almost every section have been destroyed by fire. In this section seven beds were observed 20 feet or more thick, aggregating 175 feet, and sixteen thin beds higher in the deposit aggregating 55 feet. The lower beds are of better quality than the upper ones, which are shaly and contain much woody material. While the thick seams contain some interbedded foreign material, the proportion is apparently small. The following analysis was made in the laboratory of the Geological Survey and is taken from Brooks's report, already cited:

[a] Brooks, A. H., note Collier, A. J., Coal resources of the Yukon, Alaska: Bull. U. S. Geol. Survey No. 218, 1903, pp. 44-46.

Analysis of coal from Healy Creek.

Moisture	13.
Volatile matter	18.
Fixed carbon	32.4
Ash	5.
	100.
Sulphur	.

Section on Healy Creek 2 miles above mouth.

	Fee
Overlying sands, clays, and gravels	2,50
Coal	1
Sands.	
Coal	[illegible]
Sands.	
Coal (shaly)	[illegible]
Sands.	
Coal	[illegible]
Sands and clays with two thin beds of coal	7
Coal	[illegible]
Sands.	
Coal	2
Sands	10
Coal	2
Sands	10
Coal	2
Sands and clays	5
Coal	4
Sands and clays.	
Coal (two beds)	[illegible]
White sands and gravels	7
Brown earthy shales	6
Coal	2
Covered	5
Coal	[illegible]
Dark shales and red sandstone formed by burning of the coal	1
Reddish sands with fine white gravel	2
Coal	[illegible]
Covered	10
Coal	1
Fine sandstone, white sand, and clay	1
Coal	[illegible]
Clay and nodules of sandstone	1
Alternating beds of sand and gravel	3
Clay, sand, and sandstone	1
Well-rounded gravel mixed with sand and clay	2
Clay and sand	[illegible]
Well-rounded fine wash of quartz and chert	10

Total coal, 230 feet.

LIGNITE CREEK.

In the valley of Lignite Creek, where the space between the hard-rock ridges is wider than in Healy Valley, these deposits extend from the schist ridge that limits the valley on the south to the base of Jumbo Dome, a distance of about 3 miles, and eastward till limited by the schist ridge at the head of the creek. They have been cut to depths of 1,000 feet or more by the many tributaries of Lignite Creek, which have steep grades and form where crossing the resistant coal beds waterfalls up to about 30 feet in height. These narrow cuts are clogged with masses of material from the sandy beds that break away in great blocks from the steep bluff above to form sand heaps at the bottom, and contain blocks of coal 20 feet or more in diameter.

The following sections were observed. The first is at a point about 6 miles above the mouth; the other section is about 3 miles farther upstream, near the headwaters and near the eastern limit of the occurrence.

Section on Lignite Creek 6 miles above mouth.

	Feet.
Overlying gravel.	
Thin beds coal alternating with sands and clays	250
Coal	18
Sand	10
Coal	1
Clayey sand	10
Sand, cross-bedded	100
Coal	15
Sands	100
Coal	8
Sand	75
Coal	32
Sandy clay	40
Coal	10
Sand	12
Coal	20
Sand, clay, and small amount of fine subangular quartz gravel	25
Coal (only the top of a bed exposed).	
Total coal, 129 feet.	

Section near head of Lignite Creek.

	Feet.
Overlying gravel.	
Coal (shaly)	8
Sandy clays	50
Coal	6
Clay	10
Coal	12
Sands.	
Coal	1
Gray sand and gravel, clayey toward top	40
Coal	1½
Friable clays	10

	Feet.
Clean sand	20
Coal	1
Sandy clays	2
Cross-bedded gray sands and fine gravels	50
Ferruginous sandstone	2
Coal	6
Thin-bedded sands	100
Coal	10
Sticky clay	25

Total coal, 45 feet.

The valleys of these two creeks contain a large amount of coal. The conditions for transportation in the absence of a railroad are bad. The Cantwell is an unnavigable stream and the locality is about 50 miles south of the Tanana. It would seem that if the developments in the Fairbanks region should justify it the energy of these coals might best be transported in the form of electricity. The distance across country to Fairbanks, about 75 miles, is well within the practicable limits of such an undertaking.

OTHER AREAS.

In the area to the east wherever these deposits are cut to a sufficient depth the coal-bearing beds are exposed. They occur on Coal Creek, a small tributary of Totatlanika Creek, where they are used to a slight extent by the miners, and on Mystic Creek, about 2 miles from Wood River, where two beds 20 feet and 12 feet thick were exposed in a section 80 feet high. They are reported to occur also east of Wood River. There are approximately 600 square miles of these younger deposits between Cantwell and Wood rivers. To what extent they are underlain by coal has of course not been determined. The coal-bearing beds, too, probably vary greatly in number and thickness and furthermore have been in many places burned. The continuations of the coal beds of Healy Creek outcrop on the west side of Cantwell River, and it is very probable that there is considerable coal between Cantwell and Toklat rivers. Coal occurs farther to the southwest in local disconnected areas, and in the Kantishna region is used to a small extent.

INDEX.

CLASSIFICATION OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 314.]

The publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists can be had on application.

Most of the above publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained, free of charge (except classes 2, 7, and 8), on application.
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3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost.
4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they can be consulted by those interested.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This paper is the ninety-fourth in Series A, the complete list of which follows (PP=Professional Paper; B=Bulletin; WS=Water-Supply Paper):

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——— Account of an expedition to the vicinity of Mount St. Elias in 1890. In Twelfth Ann. Rept., pt. 1, 1891, pp. 59–61. A full report of this expedition was published in Nat. Geog. Mag., vol. 3, 1892, pp. 53–203. (Out of stock.)

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Map of Alaska, showing known gold-bearing rocks, with descriptive text containing sketches of the geography, geology, and gold deposits and routes to the gold fields. Prepared in accordance with Public Resolution No. 3 of the Fifty-fifth Congress, second session, approved January 20, 1898. Printed in the engraving and printing division of the United States Geological Survey, Washington, D. C., 1898. 44 pp., 1 map. A special publication. The data were brought together by S. F. Emmons, aided by W. H. Dall and F. C. Schrader. (Out of stock.)

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Walcott, C. D., *Director*. Account of operations in Alaska in 1898–99. In Twentieth Ann. Rept., pt. 1, 1899, pp. 12, 52–53, 97, 126–134. (Out of stock.)

Maps and descriptions of routes of exploration in Alaska in 1898, with general information concerning the Territory. (Ten maps in accompanying envelope.) Prepared in accordance with Public Resolution No. 25 of the Fifty-fifth Congress, third session, approved March 1, 1899. Printed in the engraving and printing division of the United States Geological Survey, Washington, D. C., 1899. 138 pp., 10 maps in accompanying envelope. A special publication. Contributors: G. H. Eldridge, Robert Muldrow, J. E. Spurr, W. S. Post, W. C. Mendenhall, F. C. Schrader, W. J. Peters, A. H. Brooks, and E. C. Barnard. (Out of stock.)

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BROOKS, A. H. An occurrence of stream tin in the York region, Alaska. In Mineral Resources of the U. S. for 1900, 1901, pp. 267–271. Published also as a separate. Washington, Government Printing Office, 1901, cover and pp. 1–5.

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Topographic Maps of Alaska.

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Casadepaga quadrangle, Seward Peninsula; scale, 1:62500. T. G. Gerdine.

Fortymile quadrangle; scale, 1:250000. E. C. Barnard.

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Juneau Special quadrangle; scale, 1:62500. W. J. Peters.

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